

Review

The Latest Diagnostic Imaging Technologies and AI: Applications for Melanoma Surveillance Toward Precision Oncology

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Abstract

In recent years, the medical field has witnessed the rapid expansion and refinement of omics and imaging technologies, which have profoundly transformed patient surveillance and monitoring strategies, with stage-adapted protocols and cross-sectional imaging important in high-risk follow-up. In the melanoma context, diagnostic imaging plays a pivotal role in disease staging, follow-up and evaluation of therapeutic response. Moreover, the emergence of Artificial Intelligence (AI) has further driven the transition toward precision medicine, emphasizing the complexity and individuality of each patient: AI/Radiomics pipelines are increasingly supporting lesion characterization and response prediction within clinical workflows. Consequently, it is essential to emphasize the significant potential of quantitative imaging techniques and radiomic applications, as well as the role of AI in improving diagnostic accuracy and enabling personalized oncologic treatment. Early evidence demonstrates increased sensitivity and specificity, along with a reduction in unnecessary biopsies and imaging procedures, within selected care approaches. In this review, we will outline the current clinical guidelines for the management of melanoma patients and use them as a framework to explore and evaluate advanced imaging approaches and their potential contributions. Specifically, we compare the recommendations of major societies such as NCCN, which advocates more intensive imaging for stages IIB–IV; ESMO and AIOM, which recommend symptom-driven surveillance; and SIGN, which discourages routine imaging in the absence of clinical suspicion. Furthermore, we will describe the latest imaging technologies and the integration of AI-based tools for developing predictive models to actively support therapeutic decision-making and patient care. The conclusions will focus on the prospective role of novel imaging modalities in advancing precision oncology, improving patient outcomes and optimizing the allocation



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of clinical resources. Overall, the current evidences support a stage-adapted surveillance strategy (ultrasound $\pm$ elastography for lymph node regions, targeted brain MRI in high-risk patients, selective use of DECT or total-body MRI) combined with rigorously validated AI-based decision support systems to personalize follow-up, streamline workflows and optimize resource utilization.

Keywords: melanoma; diagnostic imaging; precision oncology; quantitative imaging; radiomics; artificial intelligence

1. Introduction

The recent development of sophisticated and sensitive technologies has profoundly reshaped the management of cancer patients, underscoring the centrality of individual biological variability in terms of pathological characteristics and therapeutic response. Each patient exhibits unique genetic, molecular and phenotypic profiles; consequently, future directions in oncology must inevitably converge toward precision medicine [1,2]. This paradigm is particularly relevant for biologically complex malignancies such as melanoma, which represents a model disease for studying intra-tumoral and intertumoral heterogeneity. Indeed, advanced melanoma is characterized by remarkable genetic and phenotypic diversity, often involving multiple coexisting subclones that contribute to therapeutic resistance and disease progression [3–5]. Such complexity highlights the necessity of an integrative, multi-omic approach that combines genomic information with advanced imaging data to achieve a more comprehensive understanding of tumor biology. Integrating genomic, transcriptomic, and proteomic datasets with imaging-derived features provides a multidimensional framework capable of correlating molecular alterations with quantitative and qualitative imaging phenotypes, thereby enhancing diagnostic precision, prognostic accuracy, and therapeutic stratification [5]. Recent advances in imaging technologies have significantly expanded the potential of precision oncology. Modern imaging modalities not only support disease staging and longitudinal monitoring but also generate quantitative data that objectively capture spatial and temporal aspects of tumor heterogeneity, angiogenesis and immune microenvironment dynamics [6]. The ability of imaging to deliver both quantitative biomarkers and qualitative assessments of tissue architecture complements genomic data, enabling a more integrative and biologically informed characterization of melanoma. Despite their promise, the routine clinical implementation of these technologies remains limited due to high costs, long learning curves and the challenges inherent in aligning imaging outputs with molecular datasets. Nonetheless, emerging evidence indicates that such integration can already yield significant clinical insights, particularly by providing objective, reproducible and quantifiable imaging metrics that reflect underlying genomic and molecular processes. In this scenario, Artificial Intelligence (AI) plays a pivotal role in the synthesis and interpretation of radiogenomic information. AI-driven models can analyze high-dimensional, multimodal data, bridging imaging phenotypes with genomic signatures to elucidate disease mechanisms, predict therapeutic responses, and optimize individualized treatment pathways [7]. When embedded within imaging systems, AI enhances diagnostic precision, accelerates image interpretation, and facilitates the detection of subtle and complex disease patterns that may correspond to specific molecular alterations.

This review aims to critically examine the most advanced imaging techniques currently applied in melanoma management and to explore how their integration with genomic data, further empowered by AI-based analytical frameworks, can redefine diagnostic, prognostic and therapeutic strategies within the evolving landscape of precision oncology.

2. Melanoma Management Guidelines

As emphasized by the most recent international guidelines, melanoma follow-up strategies vary substantially according to the stage of disease, making it essential to establish a structured framework that reflects these differences in clinical management. Table 1 summarizes some of the most relevant guidelines that provide clear recommendations for melanoma surveillance. We summarized the recommendations, reporting the quality and strength according to each guideline's original grading system. The National Comprehensive Cancer Network (NCCN) uses categories 1, 2A, and 2B (reflecting both evidence and consensus), while Associazione Italiana di Oncologia Medica (AIOM) and Scottish Intercollegiate Guidelines Network (SIGN) adopt the GRADE approach (certainty of evidence: high to very low; strength of recommendation: strong or conditional). European Society of Medical Oncology (ESMO) reports both the level of evidence and the strength of recommendation. The American Joint Committee on Cancer (AJCC), being a staging system (TNM), does not provide such classifications.

Table 1. Melanoma Follow-up Guidelines.

Guidelines	Follow-Up (Frequency)	Recommended Imaging	Specific Approach	References
AJCC 2018	- Does not specify follow-up protocols; focused on staging.	- It does not provide specific recommendations on imaging.	- Detailed staging: provides criteria for TNM classification of melanoma.	[8]
AIOM 2023	- Stage I–IIA: every 6 months for 5 years. - Stage IIB–IV: every 3–4 months for 2 years, then every 6 months until the 5th year.	- Ultrasound: every 6 months for 3 years (especially if no complete lymph node dissection) (Stage III). - Stage IIB–IV: CT chest-abdomen-pelvis every 6 months for 3 years, then annually until year 5. - Stage III–IV: consider annual brain MRI.	- Laboratory tests: LDH and CBC for stages IIB–IV. - Patient education: detailed instructions on self-examination and signs of recurrence.	[9]
SIGN 2023	- Stage IA: every 12 months for 5 years. - Stage IB–IIA: every 6 months for 5 years. - Stage IIB–IV: every 3 months for 3 years, then every 6 months until the 5th year.	- Imaging is not routinely recommended. - Performed only if clinical symptoms or signs of recurrence are present. - Lymph node ultrasound may be considered if clinical suspicion arises.	- Psychological support: emphasis on the importance of emotional and psychological support. - Patient education: promotion of self-monitoring and symptom awareness.	[10]
ESMO 2024	- Stage I–II: every 6 months for 5 years. - Stage III: every 3 months for 3 years, then every 6 months until the 5th year. - Stage IV: individualized follow-up.	- Ultrasound: may be performed every 3–6 months for regional disease (Stage III), as part of routine follow-up. - Stage III: CT or PET/CT scan every 6 months for 3 years, then annually. - Stage IV: imaging based on clinical presentation.	- Laboratory tests: LDH for stages III–IV. - Psychological support: attention to mental well-being during follow-up.	[11]
NCCN 2024	- Stage 0–IIA: every 6–12 months for 5 years, then annually. - Stage IIB–IV: every 3–6 months for 2 years, every 3–12 months for the next 3 years, then annually.	- Ultrasound: may be used if physical exam is inconclusive or in high-risk patients. - Stage IIB–IV: consider CT with contrast or PET/CT every 3–12 months for 2–5 years. - Stage III: consider brain MRI every 3–12 months for 2–5 years.	- Laboratory tests: LDH for stages IIB–IV. - Patient education: monthly skin and lymph node self-examination. - Genetic counseling: for patients with significant family history.	[12]

Imaging modalities such as Positron Emission Tomography/Computed Tomography (PET/CT), Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) are primarily recommended for patients with advanced-stage disease or in cases where recurrence is clinically suspected. In general, all major guidelines emphasize the importance of regular clinical evaluation, typically every 3–6 months during the initial post-treatment years, with longer intervals thereafter in the absence of recurrence. Notably, the NCCN guidelines advocate for a more intensive surveillance strategy in advanced melanoma, with detailed recommendations on the frequency and duration of imaging, particularly the use of PET/CT. In contrast, both the ESMO and AIOM guidelines recommend a more conservative approach, prioritizing clinical assessment and reserving advanced imaging for specific clinical indications. Similarly, the SIGN guidelines restrict routine imaging and underscore the importance of supporting patients’ psychological well-being, highlighting the role of empathetic communication during follow-up. By comparison, the AJCC does not provide surveillance protocols, focusing instead on staging systems and treatment decision-making. Although these guidelines share the overarching objective of ensuring timely and effective melanoma management, they differ in their approaches to follow-up, reflecting variations in clinical priorities, healthcare system structures and patient-specific risk profiles. Clinicians are therefore encouraged to remain updated on evolving recommendations and to tailor follow-up strategies accordingly, with an emphasis on opportunities for personalization and continuous improvement in patient care [8,11,12].

3. Imaging in Melanoma Management

Diagnostic imaging is central to the management and surveillance of melanoma, serving a pivotal role throughout the entire clinical pathway from early diagnosis to staging, therapeutic monitoring, and follow-up. In accordance with the major guidelines discussed above, the selection of the most appropriate imaging modality depends on disease stage, risk of progression, and individual patient characteristics. Conventional imaging technologies remain a cornerstone of clinical practice, increasingly complemented by quantitative analysis and artificial intelligence, which enhance diagnostic accuracy and support the implementation of precision medicine.

Diagnostic Imaging in Melanoma: An Overview of Ultrasound (US), CT, MRI, and PET/CT

Imaging in melanoma relies on four principal modalities: Ultrasound (US), CT, MRI and PET/CT. Each of these techniques has well-established and specific indications, consistently recognized in both clinical practice and international guidelines (Table 2).

Table 2. Conventional imaging modalities employed in the diagnosis and management of melanoma [13–18].

	Ultrasonography (US)	Computed Tomography (CT)	Magnetic Resonance Imaging (MRI)	Positron Emission Tomography (Pet)
Sensitivity	≈80–90% (regional lymph-node metastases)	≈65–75% (pulmonary metastases; size-dependent)	≈85–95% (brain metastases; high for marrow / soft tissue)	≈80–90% (distant metastases in FDG-avid tumors)
Specificity	≈85–98%	≈80–90%	≥90%	≈85–95%
Key clinical Indication	Lesion thickness; nodal assessment; superficial metastases	Staging of chest/abdomen/pelvis; lung metastases; osseous lesions	Brain/spinal cord staging; soft-tissue & bone-marrow metastases; liver characterization	Advanced staging; occult metastases; treatment response; whole-body survey
Advantages	Non-invasive; high resolution for superficial tissues/nodes; bedside	Rapid whole-body overview; excellent for deep lesions; widely available	No ionizing radiation; excellent soft-tissue contrast; multiparametric	Metabolic + anatomic information; high whole-body sensitivity
Limitations	Operator-dependent; limited depth penetration; small nodules may be missed; inflammatory nodes false-positive	Lower accuracy for brain/small nodes; ionizing radiation; iodinated contrast risks	Longer exam; motion sensitivity; higher cost; less sensitive for lungs	Cost; limited spatial resolution; small/regional nodes may be missed; hyperglycemia degrades quality

Table 2. *Cont.*

	Ultrasonography (US)	Computed Tomography (CT)	Magnetic Resonance Imaging (MRI)	Positron Emission Tomography (Pet)
Ionizing Radiation	No	Yes	No	Yes (radiotracer + CT)
Contrast Agent	None routinely (CEUS optional)	Iodinated IV often required	GBCA often useful	18F-FDG; iodinated CT contrast sometimes used
Typical Duration	≈10–20 min	≈5–15 min	≈20–45 min	≈90–120 min (uptake + scan)
Contraindications/Precautions	No absolute contraindications; limited by obesity/subcutaneous air; CEUS: caution in severe cardiopulmonary instability	Pregnancy (relative); severe CKD or prior severe iodinated-contrast reaction	Non MR conditional implants; severe claustrophobia; severe renal impairment (rare NSF risk with some GBCAs)	Pregnancy/lactation (precautions); uncontrolled hyperglycemia

US is a key imaging modality in melanoma management. It is particularly recommended for the evaluation of primary cutaneous lesions and regional lymph nodes, including sentinel lymph node assessment, as well as for surgical staging in both preoperative and postoperative settings [13,19]. As a non-invasive, cost-effective tool, US allows for repeated assessments during follow-up without exposing patients to ionizing radiation [20]. Despite its limited utility in the evaluation of deep structures and visceral metastases, US remains a first-line technique and can be effectively integrated into multimodal strategies for comprehensive staging [21]. CT is an integral component of the initial staging of advanced melanoma and is widely employed for the detection and monitoring of metastatic disease, therapeutic response, and follow-up [22]. According to the major international guidelines, including NCCN, ESMO and AIOM, contrast-enhanced total-body CT (chest, abdomen, pelvis) is recommended for patients with stage III–IV or high-risk melanoma, with specific indications for the identification of visceral metastases in the lungs, liver, lymph nodes and bones [11,23]. CT also serves as a reference tool for disease monitoring during immunotherapy and targeted therapies, offering rapid, standardized assessments with high interobserver reproducibility [22]. MRI plays a critical role in melanoma management, particularly due to the tumor's strong tendency to metastasize to the brain at an early stage. It provides superior visualization and detection of brain metastases and perilesional edema compared with other imaging modalities [24]. The addition of post-contrast T1-weighted sequences, T2-FLAIR, and diffusion-weighted imaging (DWI) further enhances sensitivity for detecting small lesions [24]. Beyond neuroimaging, MRI is also valuable in loco-regional assessments, such as the evaluation of recurrences in the head and neck or anorectal regions [25]. Importantly, the absence of ionizing radiation makes MRI particularly advantageous for long-term surveillance in patients at high risk of brain metastasis or local recurrence, where repeated imaging is frequently required [26]. PET/CT combines morphological information with functional assessment of tumor metabolic activity [27]. This modality enables the detection of occult metastases, including those at atypical sites such as bone marrow, spleen, and deep lymph nodes [28,29]. PET/CT is also widely used for monitoring therapeutic response during immunotherapy and targeted therapy [30,31]. By exploiting differences in carbohydrate metabolism, it facilitates the distinction between active lesions and post-treatment scarring [32]. Furthermore, PET/CT is indicated for staging advanced disease and evaluating suspected recurrence when findings are not conclusive with other imaging modalities [32].

4. Emerging Radiological Technologies in Melanoma Diagnosis and Management: Current Applications and Future Perspectives

New radiological technologies can revolutionize the management and diagnosis of melanoma. Techniques such as High Frequency Ultrasonography (HFUS), elastography, photon-counting computed tomography (PCCT), dual-energy computed tomography

(DECT) and whole-body magnetic resonance imaging (Whole-Body MRI) are gaining increasing attention for their ability to provide high-resolution images and additional information on tumour characterization. The implementation of these technologies promises to optimize treatments and improve clinical outcomes (Table 3).

Table 3. Overview of the clinical adoption status of emerging imaging technologies for melanoma management.

Technology	Clinical Use Status	Adoption in Clinical Centers	Level of Clinical Validation	Key Clinical Notes
HFUS	Used in specialized clinical settings	High in advanced dermatology centers	Moderate (thickness assessment, lymph nodes)	Excellent resolution for superficial lesions; useful in follow-up.
Elastography	Gradually entering clinical practice	Medium-high	Moderate (especially lymph node evaluation)	Useful for distinguishing reactive vs. metastatic tissues.
DECT	Limited use in research or specialized centers	Medium	Limited	Enhances contrast and metastasis detection with lower radiation.
PCCT	In preclinical and experimental use	Low	Low	High resolution; promising but costly and not yet standard.
WB-MRI	Selective use in advanced clinical settings	Medium	Good (prospective studies in follow-up)	Sensitive for distant and bone metastases; limited for lung assessment.

4.1. High Frequency Ultrasonography (HFUS)

HFUS is a targeted and precise imaging technique that enables more accurate and, in some cases, even preventive evaluations compared to conventional US. HFUS probes typically operate at frequencies between 15 and 22 MHz, providing visualization of the epidermis, dermis and adjacent tissues up to 1–2 cm beneath the basal layer [14]. Probes are generally classified as high-frequency (15–22 MHz) or ultra-high-frequency (up to 70 MHz), the latter offering submillimeter resolution of superficial structures [14,33]. In some instances, devices operating at frequencies of up to 30 MHz can also achieve submillimeter resolution of superficial anatomical features [34,35]. With probe frequencies ranging from 14 to 100 MHz, HFUS achieves a resolution of up to 30 microns and a penetration depth of 15 mm. The exceptional resolution of HFUS allows detailed visualization of skin layers and adnexal structures, extending to near-histological detail [36]. Its possible role in the preoperative assessment of melanoma, where findings can be correlated with histopathology, has been proposed in recent years [37], and it has obtained the best results in melanoma with lesion thickness >2 mm. In melanoma surveillance, where US has a recognized role, HFUS is employed in detecting in-transit metastases and satellitosis, demonstrating superior performance (in terms of sensitivity and specificity) in small and superficial lesions compared to conventional ultrasound [38–40]. Its potential utility has also been suggested in the assessment of post-surgical scarring, particularly in high-grade melanomas, as well as in the early detection of local recurrence. HFUS could play a role also in the surveillance of regional lymph node basins. However, its widespread adoption is limited by the need for specialized training and the high cost of equipment. Although further validation is required, HFUS represents a promising tool that warrants dedicated investigation [41].

4.2. Elastography

Elastography is a real-time imaging modality that, when combined with conventional US, allows for the evaluation of tissue elasticity and the discrimination of pathological alterations such as fibrosis or neoplastic lesions [42]. By assessing tissue stiffness, elastography provides qualitative information that differentiates normal from abnormal tissues, while at a quantitative level it measures parameters such as elastic wave velocity or strain ratio, which are instrumental in characterizing suspicious lesions [43]. Although most modern US systems incorporate elastographic capabilities, its routine clinical application remains limited due to the absence of universally accepted quantitative cut-off values, across various clinical indications. Shared thresholds are currently being established in specific fields such as breast and thyroid imaging [44–46]. Consequently, elastography is more frequently employed as a qualitative adjunctive tool, complementing conventional ultrasound and enhancing overall diagnostic accuracy. Two main elastographic approaches are currently in use: strain elastography and shear-wave elastography (SWE). Strain elastography provides a visual assessment of tissue deformability relative to surrounding structures, thereby facilitating the distinction between healthy and pathological tissue. In contrast, SWE offers a quantitative evaluation of tissue stiffness, enabling more objective lesion characterization. Both techniques contribute significantly to preoperative lesion assessment and assist in optimizing biopsy site selection for histopathological analysis [47,48]. Elastography has also demonstrated potential in the differential diagnosis of lymph node metastases, particularly in the cervical, inguinal and axillary regions [49,50]. In a study by Dai Ogata and collaborators, the authors explored the capability of elastography to distinguish reactive from metastatic lymph nodes in patients with cutaneous malignant melanoma in real time. 20 lymph nodes from 12 patients were examined using both elastography and B-mode US. Elastography scores (ES) ranging from 1 to 5 were assigned according to tissue stiffness and subsequently correlated with histopathological findings. The results showed that elastography achieved superior diagnostic accuracy compared with conventional US, with an optimal ES cut-off value of 4. This approach may enhance the early detection of metastatic lymph nodes and reduce dependence on sentinel lymph node biopsy, offering a non-invasive alternative for patient evaluation [42]. Similarly, in another study the researchers investigated the combined use of elastography and B-mode US in the surveillance of lymph node metastases among melanoma patients. In a cohort of 49 patients encompassing 108 lymph nodes, 17 of which were histologically confirmed metastases, elastography proved particularly effective in the early detection of metastatic involvement, especially in subcentimeter lymph nodes and demonstrated high diagnostic performance in classifying nodal consistency [51]. Furthermore, elastography may hold potential in the evaluation of in-transit metastases following local treatments such as electrochemotherapy or surgical resection, by aiding in the differentiation of new small lesions from post-therapeutic changes. Its capacity to detect metastatic lymph node involvement at an early stage underscores its value in melanoma clinical management and follow-up. The ability to provide real-time, non-invasive, and functionally relevant information further highlights the clinical promise of elastography and supports the need for continued investigation and standardization in this emerging field.

4.3. Photon Counting CT (PCCT) and Dual Energy CT (DECT)

PCCT represents an innovative imaging technology that employs advanced photon-counting detectors (PCDs) to achieve higher spatial resolution, lower radiation exposure and enhanced spectral imaging compared with conventional CT methods. PCDs are composed of semiconductors that directly convert incoming X-ray photons into electrical pulses according to their energy level [52]. This direct conversion process significantly reduces

radiation dose requirements while preserving image quality. Furthermore, PCCT minimizes beam-hardening artefacts, optimizes contrast utilization and enables quantitative imaging, offering substantial advantages over standard CT techniques [53]. In oncological contexts, PCCT offers important advantages: 1. head and neck: it provides suitable image resolution for evaluating laryngeal cartilage and skull base infiltrates, reducing artefacts and improving tissue contrast; 2. chest and breast: it provides better spatial resolution for peripheral lung structures, nodules and interstitial disease; 3. abdomen and pelvis: it allows arteries, veins and liver lesions to be distinguished in a single scan due to spectral separation of contrast agents, reducing the number of scans needed; 4. bone: it improves resolution of trabecular structure, useful for assessing bone density, fractures and metastases [54]. DECT, on the other hand, allows the acquisition of CT images at two different energy spectra. This results in a better differentiation of certain materials (i.e., iodine and calcium) improved lesion visualization and contrast. DECT examination is based on the fact that materials have unique attenuation profiles at different energy levels, according to their linear attenuation coefficient. Thus, when exposed to low and high-energy polychromatic X-ray beams, materials with low atomic numbers (e.g., water) or with high atomic numbers (e.g., iodine) show differences in attenuation during DECT examination [55]. Several studies reported DECT diagnostic ability in oncology patients, not only in lesion characterization but also in detecting lesion response after therapy [55,56]. In particular, DECT has proven especially effective in detecting and monitoring metastases from malignant melanoma [55,57,58]. In melanoma, DECT enables better identification of metastatic lesions, including lung nodules, liver and kidney masses and optimizes their follow-up [59–61]. Several studies have demonstrated that DECT improves the detection of skin and lymph node metastases, increasing detection rates from 86% to 94%, while also reducing radiation dose compared to conventional CT [58,61].

Both PCCT and DECT offer significant advantages over conventional CT, although they differ in specific applications and benefits:

1. **Spatial Resolution:** PCCT excels in visualizing peripheral trabecular and pulmonary structures, whereas DECT is particularly effective in detecting metastases through spectral imaging of iodinated contrast.
2. **Dose Reduction:** Both techniques contribute to radiation dose reduction, with DECT specifically optimizing dose by separating tissues based on their chemical composition.
3. **Spectral Imaging:** PCCT provides superior energy separation with minimal spectral overlap, while DECT employs advanced algorithms to enhance the diagnostic quality of spectral images.
4. **Clinical Applications:** PCCT is ideal for structural assessment, such as bone density evaluation or infiltration analysis, whereas DECT is particularly suited for oncologic imaging, including metastasis staging and monitoring.

In conclusion, PCCT and DECT are complementary technologies addressing different diagnostic needs, offering optimal solutions in specific clinical scenarios. Although not yet used routinely, their adoption is increasing due to their advantages in diagnostic accuracy, reduced radiation dose, and improved tissue characterization, making them highly valuable in oncological and cardiovascular imaging [62,63].

4.4. Whole-Body Magnetic Resonance Imaging (WB-MRI)

WB-MRI is not considered a primary screening modality according to American and European guidelines [8,64]. Nevertheless, it plays a critical role in cancer staging, in particular for melanoma [16]. DWI further enhances diagnostic sensitivity and specificity for detecting malignant lesions [65–67]. Several studies have evaluated the utility of WB-MRI compared to conventional imaging techniques such as CT and PET/CT [67]. In

patients at high risk of recurrence, WB-MRI enables early identification of micro-metastatic lesions, undetectable by other diagnostic methods [68]. Reinert and collaborates demonstrated that, by providing more precise disease staging, WB-MRI significantly influenced therapeutic decision-making in a substantial proportion of patients. In this study, the researchers compared the diagnostic performance of WB-MRI with CT and PET/CT using 18F-Fluorodeoxyglucose (F-FDG) in 57 patients with metastatic melanoma. Patients underwent PET/CT and PET/MRI on the same day, with scans independently evaluated by two radiologists. Results were analyzed across four regions: lymph nodes/soft tissues, lungs, abdomen/pelvis, and bones. CT demonstrated higher sensitivity for pulmonary lesions, whereas MRI detected more metastases in bones. Inter-reader agreement varied by region, with the highest agreement observed in the abdomen/pelvis. Overall, WB-MRI emerged as a promising alternative to CT, offering comparable diagnostic performance with some limitations in detecting pulmonary lesions [16]. In a study conducted by Yanina JL Jansen et al., 111 patients with stage IIIB/C or IV melanoma (either disease-free after resection of macro-metastases or with durable response to systemic therapy) were monitored using WB-MRI. The protocol included T1-weighted sequences, Short Tau Inversion Recovery (STIR) and DWI performed every 4 months for the first 3 years and every 6 months for the subsequent 2 years. During follow-up, 26 suspicious lesions were identified, 15 of which were confirmed as recurrences via MRI. The study reported an overall sensitivity of 58% and specificity of 98%, with sensitivity for detecting distant metastases reaching 88% [68].

Therefore, WB-MRI is a vital tool for evaluating and monitoring melanoma due to its ability to provide detailed imaging. As highlighted above and supported by extensive literature, the combination of WB-MRI and PET/CT could enhance conventional CT in detecting advanced-stage melanoma metastases. Additionally, WB-MRI is a radiation-free technique that can be integrated into surveillance protocols to monitor disease recurrence, optimize therapeutic management, and improve patient prognosis. Despite the many benefits, WB-MRI is currently a relatively long examination, lasting around 45–70 min, causing greater discomfort for patients. Furthermore, this method is still not sufficiently uniform among the various centres and the costs are not low [69,70].

4.5. Clinical Development Directions

Emerging radiological techniques in melanoma require validation, specialized training and careful management to ensure economic sustainability. While these methods have demonstrated high applicability, their widespread use is currently limited by the need for standardization, high costs and unequal access. In this context, AI and radiomics have the potential to enhance the accuracy, sensitivity and specificity of these imaging modalities. A multimodal approach, integrating clinical and molecular data with advanced imaging, can directly contribute to personalized medicine. In line with these perspectives, a recent international review on AI for melanoma detection highlights that translating high performance on research datasets into real world use requires shared benchmarks, harmonized metrics and multicenter prospective trials. It also recommends integrating models into radiology workflows (PACS/EHR) with continuous performance auditing and adequate explainability for clinicians. These points are consistent with a multimodal strategy that fuses advanced imaging with clinical and molecular data to personalize melanoma management [71]. Currently, only HFUS and elastography have established clinical applications, whereas PCCT, DECT and WB-MRI are mainly used in preclinical or clinical studies [44,72–75]. In addition, each emerging technique presents specific challenges and near term opportunities: HFUS offers submillimeter resolution for superficial and in transit disease but it is limited by operator dependence and shallow penetration; elastography improves nodal characterization yet lacks vendor independent cutoffs; DECT

enhances lesion conspicuity via iodine maps but requires protocol harmonization; PCCT promises superior spatial/spectral resolution though availability and cost remain barriers; WB-MRI, valuable for bone and distant disease, is constrained by long exam times and lower pulmonary performance. In the future, these emerging techniques could become routine tools for staging, follow-up and early evaluation of therapeutic response. Progress will likely depend on standardization (protocols, QA/QC, shared phantoms), multicenter prospective validation and practical AI integration (automated segmentation, longitudinal quantitation, decision support) embedded in clinical workflows. Table 4 provide a comparative overview of standard and emerging imaging techniques in the management of melanoma, highlighting their advantages, limitations and clinical development status. Standard techniques are widely available and supported by established protocols, but they are associated with high costs, radiation exposure and limitations for prolonged follow-up. New techniques, although requiring dedicated infrastructure and specialized training, offer advantages such as high spatial resolution, lower radiation exposure and potential integration with AI. In this regard, a 2023 review on advances in machine learning for melanoma diagnosis and prognosis highlights the increasing performance of deep learning applied to clinical images, dermoscopic images and digital histopathology slides, as well as the development of emerging prognostic tools. However, translating these advancements into clinical practice requires high-quality datasets with more detailed annotations, harmonized evaluation metrics and multicenter validation [76]. Assessments of sensitivity and suitability for follow-up are largely based on preliminary data, particularly for WB-MRI and HFUS. The main challenges include operator dependence and the lack of standardized protocols. Targeted training, inter-vendor harmonization, and prospective real-world evaluation will be essential to translate these advances into durable clinical benefit.

Table 4. Comparison of standard and emerging imaging techniques in the management of melanoma.

Parameter	Standard Imaging (US, CT, MRI, PET/CT)	Emerging Imaging (HFUS, Elastography, DECT, PCCT, WB-MRI)
Clinical Availability	High	Variable to low (depends on the technique and setting)
Radiation Exposure	Modality dependent: US/MRI none; CT/PET-CT ionizing (Overall Medium high)	Generally lower (WB-MRI, HFUS: none; DECT/PCCT: optimized)
Cost and Infrastructure	Moderate to high	High (advanced equipment and specialized training required)
Spatial Resolution	Good	Very high (e.g., HFUS and PCCT allow submillimeter resolution)
Sensitivity for Metastatic Spread	High for visceral and nodal metastases	High in selected settings-WB-MRI: bone/distant; HFUS/Elastography: superficial and nodal characterization; DECT/PCCT: small/low contrast lesions
Suitability for Long-Term Follow-Up	Limited by radiation and cumulative exposure	Favorable (especially WB-MRI and HFUS)
Integration with AI and Radiomics	Widely used in structured clinical settings (segmentation and reporting)	High potential-HFUS/Elastography: automated measurements; DECT/PCCT: spectral/radiomics; WB-MRI: quantitative DWI
Operator Dependency	Moderate (higher for US)	High (especially for HFUS and elastography); Moderate (DECT/PCCT and WB-MRI)
Level of Standardization	Well established protocols	Still under development in many cases
Exam Time/Workflow	Short/moderate; fully integrated in routine workflow	Moderate/long (WB-MRI longer); setup/training phases for new techniques
Clinical Evidence/Adoption	Guideline supported; widely adopted	Mixed: HFUS/Elastography with focused clinical use; DECT/PCCT/WB-MRI mainly research early clinical adoption

Table 4. Cont.

Parameter	Standard Imaging (US, CT, MRI, PET/CT)	Emerging Imaging (HFUS, Elastography, DECT, PCCT, WB-MRI)
Melanoma specific strengths (examples)	PET/CT: systemic staging/therapy response; CT: lung/viscera; MRI: brain/soft tissue; US: nodal assessment	HFUS: sub-mm superficial and in transit disease; Elastography: nodal stiffness; DECT: iodine maps conspicuity; PCCT: high spatial/spectral, fewer artifacts; WB-MRI: whole-body marrow and bone metastasis
Main limitations/challenges	Radiation (CT/PET-CT); limited sensitivity for tiny/in transit lesions; cost of repeated imaging	HFUS: operator dependence, shallow penetration; Elastography: no shared cut-offs, vendor variability; DECT/PCCT: access, spectral harmonization, residual dose; WB-MRI: long exams, lower pulmonary performance, inter center heterogeneity
Near term development priorities	Dose/contrast optimization; structured reporting; value based follow-up; pragmatic AI QA/monitoring	Standardized training and protocols (HFUS); multicenter quantitative thresholds (Elastography); harmonized spectral protocols and iodine density biomarkers + radiomics (DECT/PCCT); abbreviated, quantitative DWI pathways and reporting templates (WB-MRI)

5. Artificial Intelligence as a Decision Support Tool for Melanoma: Comparative Analysis of Imaging Modalities

AI is becoming fundamental in clinical decision support and surveillance of many diseases. In particular, deep learning has proven to be a highly effective tool for image analysis and, in the future, could complement direct patient care under the supervision of medical specialists [77]. In metastatic melanoma surveillance, AI has the potential to significantly improve sensitivity and specificity. Several studies have demonstrated that its performance in image-based diagnosis is not inferior to that of qualified dermatologists [78–80]. Over the years, multiple surveys have explored the integration of AI into clinical practice, highlighting both its potential and the challenges for widespread adoption. In a 2019 survey, physicians approved AI use, but they felt that diagnostic decision making should remain in the hands of specialists. Later, in 2021, concerns emerged about the possibility that AI could make mistakes, raising doubts about its reliability. In contrast, a survey targeting patients highlighted AI benefits, such as faster diagnoses and better health care, while expressing concerns about the possible inaccuracy of a diagnosis provided by a digital platform rather than a physician [81–83]. Recent studies have confirmed that AI performance can match, and in some cases exceed, that of medical specialists, thereby enhancing the diagnostic process. Phillips and coworkers, in a meta-analysis of several convolutional neural network (CNN) algorithms trained on dermoscopic images, reported an AUC between 0.86 and 0.96 for melanoma diagnosis, with sensitivity ranging from 87% to 95% and specificity between 80% and 90%. These findings demonstrate that AI can effectively distinguish malignant lesions from benign ones, with performance comparable to that of clinical experts [83]. Similarly, in an observational study published in *Nature Medicine*, the authors directly compared a deep learning algorithm with 58 dermatologists in diagnosing real clinical cases. The AI demonstrated superior sensitivity in detecting malignant melanoma (95% versus 88%), confirming its potential as a support tool in daily clinical practice [84]. Traditional imaging modalities, including ultrasound, CT, MRI and PET-CT, have further improved diagnostic precision and accuracy, making them particularly valuable. Today, a variety of AI-based methods are already in routine use in hospitals worldwide, as detailed in Table 5.

Table 5. AI applications in clinical routine.

Modality	AI/Radiomics Task	Cohort/Setting	Key Metrics (If Reported)	Study
CT (standard)	Early survival estimation under ICI (anti PD-1)	n = 575; pooled KEYNOTE-002/-006; internal train/validation (validation pembrolizumab n = 287)	Time-dependent AUC at 6 months 0.92 (95% CI 0.89–0.95) vs. RECIST 1.1 0.80 (0.74–0.84)	[85]
CT (standard)	Early response/pseudoprogression identification	n = 50; single center; baseline + post-cycle 1–2 (train PD-1 n = 34/validation CTLA-4 n = 16)	Validation AUC 0.857	[86]
Dual-energy CT (DECT)	Response prediction to immunotherapy (stage IV)	n = 140; baseline DECT; chronological split 70/70; 10-fold CV for tuning	Validation AUROC patient-level SECT 0.50 vs. DECT 0.75; lesion-level SECT 0.61 vs. DECT 0.85	[87]
PET/CT (18F-FDG)	Hyper progression prediction (lesion-level) before ICI	330 lesions in 56 patients; retrospective; single center; nested cross-validation; no external validation	Testing AUC $\approx$ 0.703 (CT) $\approx$ 0.704 (PET/CT) a 3 mesi	[88]
Brain MRI	Prognosis in brain metastases (with ICI)	88 pts; 196 metastases	Radiomic features associated with OS	[89]
Brain MRI	“Virtual biopsy”: BRAF mutation prediction in brain metastases	53 pts (54 lesions); two centers	Accuracy 0.79 ± 0.13 ; AUC $\sim$ 0.78	[90]
Whole-body MRI (WB-MRI)	Emerging role of radiomics/AI for risk stratification and personalization	Narrative/systematic review on WB-MRI in melanoma	synthesis of applications and potential (no AI model performance)	[91]
Ultrasound/Elastography	Melanoma specific AI: scarcity of published studies; evidence from oncologic lymph-node AI and melanoma elastography	US-radiomics review on oncologic lymphadenopathy; feasibility in cutaneous melanoma	Indirect/feasibility evidence; need melanoma specific validation	[42,92]
Photon-counting CT (PCCT)	No melanoma specific AI/radiomics studies identified to date	Robustness studies in PCD-CT (phantom/other diseases)	Focus on feature robustness (e.g., sensitivity to pitch/slice thickness), not melanoma outcomes	[93]

Despite their advantages, traditional and advanced imaging methods have some limitations, including the need for complex equipment and dependence on the clinician’s experience. In addition, these techniques do not provide entirely objective data, as interpretation can be influenced by the clinician’s subjective judgment. HFUS, elastography, PCCT, DECT and WB-MRI offer more precise and comprehensive information but remain operator dependent. Nevertheless, their ability to generate large volumes of detailed data can help reduce subjective errors in image analysis. Consistent with this, a focused review in metastatic cutaneous melanoma shows that AI/radiomics applied to standard CT, MRI and PET can determine tumor volume, heterogeneity and shape to support diagnosis, staging, treatment planning and longitudinal monitoring across the care pathway [94]. AI can leverage data from both standard and advanced imaging techniques, recognizing complex patterns invisible to the human eye. It can also automate lesion classification (benign versus malignant) and integrate multiple data sources to improve diagnostic accuracy, thereby supporting personalized medicine. Major AI applications include: 1. automatic image segmentation using deep convolutional neural networks to identify and separate anatomical structures; 2. computer-aided diagnosis (CAD) to detect abnormalities, tumours or lesions, supporting radiologists in accurate diagnosis; 3. predictive and prognostic analysis to enable timely and personalized interventions; 4. workflow optimization, including automatic image classification [95]. In addition, AI opens analytics systems for clinical decision support, artificial neural networks for image detection, classification and segmen-

tation, machine learning for big data analysis, and deep learning, which further enhances analytics capabilities [96]. On the other hand, AI has important limitations. It requires large, high-quality datasets for both initial training and external validation. These datasets must represent diverse populations and clinical settings; otherwise, models may fail to generalize to real-world practice. Biases can arise within large datasets, including demographic bias (e.g., skin phototype), selection bias from institutional datasets and imbalances between benign and malignant cases, all of which may reduce performance in underrepresented groups. Crucially, despite technological progress, final clinical oversight remains essential to correctly interpret results and avoid over-reliance on AI. Interpretability and explainability must be prioritized to increase trust and integration into clinical workflows. Looking ahead, AI should become a routine component of basic analysis for metastatic melanoma surveillance, enhancing accuracy, precision and early detection of abnormalities.

5.1. Ethical Implications, Data Privacy and Regulatory Perspectives in Medical AI

The use of AI in the medical field has raised a number of critical ethical and regulatory issues. A systematic review by Tang and collaborators identified 36 empirical studies published between 2022 and 2023 that focused on the ethical challenges of medical AI, highlighting growing concerns within the scientific community [97]. The main issues include the protection of sensitive patient data, the need for access to large volumes of clinical images to train algorithms and the transparency of decision-making processes, including informed consent. In this context, important regulatory frameworks at the European level, such as the General Data Protection Regulation (GDPR) and the new Artificial Intelligence Act (AI Act), are highly relevant. The GDPR imposes stringent rules on the processing of personal data (<https://www.garanteprivacy.it/regolamentoue> accessed on 14 November 2025), with health data falling under “special categories” (Art. 9) that require a lawful basis and appropriate safeguards (e.g., pseudonymisation, data minimisation, and where processing is likely to be high risk a Data Protection Impact Assessment); truly anonymised data are outside the GDPR’s scope. While the AI Act, which came into force on 1 August 2024, introduces a risk-based classification system for AI applications [98]. The Act foresees staged application of obligations and delineates roles for “providers” and “deployers”, with additional duties for general-purpose AI and for systems used in regulated medical products. Under this regulation, AI tools used in medicine are classified as “high risk”, with strict requirements regarding safety, human supervision, traceability, auditability and technical documentation. When the AI system is a medical device or a safety component under the MDR/IVDR, further obligations apply, including risk management, detailed logging, human oversight, registration and continuous post-market monitoring. Currently, there are no harmonized informed consent models at the European level for AI use in healthcare, despite the emphasis on transparency and patient information in both the GDPR and AI Act. Complementary data-governance tools such as the European Health Data Space (EHDS) establish Health Data Access Bodies and “data permits” to enable privacy-preserving secondary use of health data for research and innovation, providing a structured pathway for AI development and validation. Furthermore, in June 2025, the European Commission launched a public consultation on high-risk AI in the healthcare and life sciences sectors, aiming to collect feedback from stakeholders and healthcare institutions on the main challenges associated with its implementation. In practice, compliance will require integrated governance (GDPR + AI Act + MDR/IVDR), clear consent/data-access pathways, robust documentation and audit trails, external validation across centers/vendors, and continuous performance monitoring [98].

Ethical Considerations Specific to Melanoma Surveillance

The greatly varied and complex characteristics of melanoma require careful and well-structured monitoring of the disease and raise important questions about its management. Firstly, frequent radiological follow-up (especially in the early stages of the disease) focuses attention on the need to appropriately balance the harms and benefits associated with routine imaging (cumulative radiation exposure, false positives, anxiety, resource use), favouring follow-up appropriate to the stage and risk. The use of methods such as WB-MRI could reduce radiation exposure, but increases incidental findings, requiring pre-test counselling and standardised management procedures. Furthermore, it is essential to ensure proper privacy from the design stage of longitudinal images (total body photography/teledermatology) with explicit consent, secure storage and clear policies on secondary use. The implementation of fair and externally validated AI that combines the minimum necessary imaging with robust data governance and responsible oversight will be necessary.

6. Conclusions

The management of metastatic melanoma continues to be a crucial challenge in clinical practice, requiring a multidisciplinary approach based on established guidelines and effective diagnostic techniques. Current recommendations emphasize the importance of accurate staging, regular surveillance and optimization of treatment protocols, with a central role of traditional imaging techniques, such as CT, MRI and PET. These tools remain the gold standard for assessing disease progression, although they have limitations related to cost, availability and variability in image interpretation. In practice, a stage adapted strategy is warranted: ultrasound as first line for nodal basins; brain MRI targeted in stage III–IV/high-risk patients; selective use of DECT to improve lesion conspicuity/predict early response; WB-MRI for bone and distant disease (with known lung limitations). It is also important to underline that some modalities and analytic approaches require substantial disease-specific clinical expertise and entail a longer learning curve, which can impact diagnostic accuracy, reproducibility and the pace of clinical adoption. Where feasible, protocol standardization (acquisition/reconstruction) and reader training should be prioritized to improve reproducibility and reporting consistency. These methods have considerable relevance in clinical practice: the clinical benefits and potential harms must always be assessed to improve the understanding of the methods. Besides the established benefits for defining the stage of disease, the localization of metastases, and guiding treatment decisions, the possible associated risks must also be considered. These include incidental findings, which for the purposes of the method are relevant but could be unrelated to the oncologic pathology. However, these findings in most cases lead to a cascade of other examinations, with additional invasive investigations, increased costs and overload for radiology services. Therefore, decision processes should include thresholds for follow-up of incidentalomas and shared decision-making to limit diagnostic tests with low added value. Radiation exposure and adaptation of methods, to date, appears to be a topic of considerable debate. It turns out to be of crucial importance to protect vulnerable groups of patients and, in this regard, to comply with the recommendations provided by bodies such as the Health Information and Quality Authority (HIQA) regarding diagnostic reference levels for medical exposure to ionizing radiation. Operationally, apply ALARA and national DRLs (e.g., HIQA), prioritize MRI/US in young or pregnant patients, use low-dose CT protocols when appropriate, and consider WB-MRI to reduce cumulative ionizing exposure in long-term surveillance. All these aspects must be considered when choosing the most appropriate diagnostic method, balancing risks and benefits for each patient. Within a system that puts the patient at the “center”, the use of ad hoc equipment should

be evaluated, to provide a balanced clinical perspective that considers benefits and possible harms. Institutions should also monitor modality-specific dose indices and audit adherence to DRLs as part of routine quality governance. In parallel, the introduction of innovative analyses is expanding diagnostic and prognostic possibilities. Quantitative imaging technologies and radiomic applications allow more detailed tumor characterization, improving accuracy in assessing therapeutic response and predicting disease progression. Unlike diagnostic technologies, AI enables a predictive and integrative approach, being able to analyze big data and providing continuous real-time clinical support. However, their integration into clinical practice is still limited by the need for extensive validations, the high cost of infrastructure and the need for highly specialized expertise. The most mature evidence currently supports CT-based models for early survival/response estimation under immune checkpoint inhibitors, PET/CT lesion level risk signatures (e.g., hyper-progression signals) and brain MRI radiomics for prognosis and “virtual biopsy” (e.g., BRAF status) in brain metastases; evidence remains limited for ultrasound, WB-MRI and photon-counting CT in melanoma. Finally, AI represents a significant breakthrough in precision oncology. The ability to analyze large amounts of data promotes the development of predictive models that support treatment choices and improve overall patient management. The integration of AI with advanced imaging techniques not only refines diagnosis and staging but also enables more efficient use of clinical resources, including a documented reduction in unnecessary biopsies (up to 50%), shortened reporting times, and alleviation of workload pressure on radiology and dermatology departments. Before routine adoption, models should demonstrate external multicenter validation, robustness to acquisition/reconstruction variability, transparent reporting and prospective clinical utility on patient relevant endpoints. However, issues related to standardization, regulation and implementation costs remain to be addressed. Radiation exposure and the need to adapt diagnostic methods to vulnerable patient groups is currently a topic of debate. The level of exposure varies significantly based on the method we want to use and it is of fundamental importance to rigorously observe the recommendations provided by bodies, such as the HIQA, for the permitted levels of diagnostic exposure. The main vulnerable categories to consider are young patients, pregnant women and people with genetic predisposition to developing neoplasms. A pragmatic framework is to: 1. minimize ionizing studies when equivalent diagnostic alternatives exist; 2. document dose and cumulative exposure; 3. explicitly tailor surveillance intervals to age, comorbidity and treatment phase. Implementing a conservative system that evaluates the patient and the diagnostic needs is effective for diagnostic therapeutic purposes. Looking ahead, the combination of standard techniques, technological innovations and AI represents a unique opportunity to transform metastatic melanoma management. In this context, AI represents a unique tool to address the molecular and clinical complexity of the disease, supporting both early diagnosis and continuous monitoring of therapeutic response. Imaging adapted to the stage of the disease, combined with decision support based on validated AI, can personalise follow-up, anticipate therapeutic decisions and optimise the use of resources, provided that implementation is accompanied by governance in terms of data protection, bias monitoring and human supervision. An integrated approach, which also considers economic and logistical constraints, will be essential to improve the quality of care, increase patient survival and make the healthcare system more sustainable and efficient.

Priorities for the field include the harmonization of imaging and annotation protocols, the development of shared reference datasets, real-world prospective studies, and health economic evaluations to inform scalable and equitable implementation. In summary, the following key take-home messages should guide clinical practice and future research:

- Use stage-adapted imaging—ultrasound for nodal basins, brain MRI for stage III–IV disease, and selective use of DECT or whole-body MRI—while balancing diagnostic yield against radiation exposure and cost.
- Deploy AI where evidence is strongest: CT for early outcome and response assessment, PET/CT for lesion-level risk stratification, and brain MRI for prognostic evaluation. Recognize current evidence gaps for ultrasound, whole-body MRI, and photon-counting CT.
- Ensure external validation, robustness testing, and transparent reporting before routine clinical implementation, and integrate AI models into traceable, clinician-in-the-loop workflows.
- Protect vulnerable groups by adhering to DRLs and ALARA principles, prioritizing non-ionizing modalities when feasible, and auditing both dose and cumulative exposure.
- Invest in standardization, shared datasets, and prospective trials to demonstrate clinical utility and cost-effectiveness.

7. Methods

The bibliographic search for this study was conducted using PubMed/MEDLINE, Embase, Scopus and Web of Science, supplemented by targeted searches of the NCCN, ESMO, AIOM and SIGN websites. Keywords (adapted to each database) included: melanoma AND (ultrasound OR elastography OR MRI OR whole-body MRI OR CT OR dual-energy CT OR photon-counting CT OR PET/CT OR radiomics OR artificial intelligence OR deep learning) AND (diagnosis OR staging OR surveillance OR follow-up OR response assessment), with MeSH terms used where appropriate. Inclusion criteria: peer-reviewed studies in human populations, pertinent to melanoma imaging or AI/radiomics-based predictive models, reporting quantitative outcomes (e.g., sensitivity/specificity, AUC, PPV/NPV or clinical outcomes). Exclusion criteria: editorials, letters without data, single case reports, purely technical studies without clinical/diagnostic outcomes, non-peer-reviewed preprints and animal studies. Where applicable, we considered methodological quality (e.g., QUADAS-2 for diagnostic accuracy studies; PROBAST/TRIPOD for predictive models; CLAIM/QUADAS-AI principles for AI studies in imaging), using these as a narrative guide to weigh the evidence. We prioritized multicenter studies, large sample sizes, and reproducible findings; studies published before 2015 were retained only if essential for historical context or clinical practice recommendations.

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Abbreviations

The following abbreviations are used in this manuscript:

AI	Artificial Intelligence
AI Act	Artificial Intelligence Act (European Union Regulation)
AIOM	Italian Association of Medical Oncology
AJCC	American Joint Committee on Cancer
CAD	Computer-Aided Diagnosis
CNN	Convolutional Neural Network

CT	Computed Tomography
DECT	Dual-Energy Computed Tomography
DWI	Diffusion-Weighted Imaging
ESMO	European Society for Medical Oncology
GDPR	General Data Protection Regulation
HFUS	High-Frequency Ultrasound
HIQA	Health Information and Quality Authority
MRI	Magnetic Resonance Imaging
NCCN	National Comprehensive Cancer Network
PCCT	Photon-Counting Computed Tomography
PET/CT	Positron Emission Tomography/Computed Tomography
SIGN	Scottish Intercollegiate Guidelines Network
STIR	Short Tau Inversion Recovery
SWE	Shear-Wave Elastography
TLA	Three-Letter Acronym
US	Ultrasound
WB-MRI	Whole-Body Magnetic Resonance Imaging

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