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The use of artificial intelligence in magnetic resonance imaging and its importance for diagnosis: a literature review

The use of artificial intelligence in magnetic resonance imaging and is importance for diagnosis: a literature review

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Summary

In recent years, the use of artificial intelligence (AI) in healthcare has gained increasing prominence, especially in supporting imaging diagnosis. With technological advancements, AI-based systems have been applied to help healthcare professionals interpret exams more quickly, accurately, and efficiently. Therefore, this work aims to gather and analyze information on the use of AI in imaging exams, with a focus on magnetic resonance imaging (MRI), and demonstrate how this technology can contribute to faster, more accurate, and safer diagnoses. To this end, an integrative literature review was conducted, based on studies already published in major scientific databases, such as PubMed, MedLine, ACM Digital Library, SciELO, and Google Scholar, among other platforms. Articles that address the use of AI in the detection, segmentation, classification, and interpretation of medical images were selected. Thus, we analyze and discuss not only the benefits of AI, such as error reduction and optimization of analysis time, but also the challenges and limitations encountered in its practical application. Therefore, this work reinforces the importance of this technology as a tool to support imaging diagnosis and recognizes the paths for future research and innovations in the health area.

Keywords: Artificial Intelligence; Magnetic Resonance Imaging; Diagnostic Imaging.

Abstract

In recent years, artificial intelligence (AI) has increasingly been applied to medical imaging, with particular promise in magnetic resonance imaging (MRI). This integrative literature review synthesizes published evidence on AI-based approaches for detection, segmentation, classification, and interpretation of MRI studies. Searches were conducted across major scientific databases, including PubMed, MedLine, ACM Digital Library, SciELO, and Google Scholar, to identify studies that evaluate technical performance and clinical applicability of AI methods in MRI. The reviewed literature demonstrates substantial technical advances, such as improvements in image reconstruction and acceleration, noise reduction, lesion segmentation, and automated classification. These advances frequently yield high diagnostic performance metrics and reductions in acquisition or reading time.

However, most evidence remains retrospective, single-center, and benchmark-driven, limiting direct translation to routine clinical practice. Key challenges include limited external validation, data heterogeneity, model explainability, regulatory and ethical concerns, and infrastructural barriers to deployment. We conclude that AI holds real potential to enhance MRI workflow efficiency and diagnostic accuracy, but its broader clinical adoption requires prospective multicenter validation, standardized reporting, and further attention to bias, explainability, and infrastructural barriers. Future research should prioritize pragmatic trials and implementation studies that measure clinical and economic impact.

Keywords: Artificial Intelligence; Magnetic Resonance Imaging; Diagnostic Imaging.

1. Introduction

Magnetic resonance imaging (MRI) is an accurate, non-invasive imaging method that uses principles

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of nuclear physics to generate detailed images of the inside of the human body. The examination is based on interaction between magnetic fields and the hydrogen nuclei present in the tissues, which allows obtain detailed images of the different internal structures. Because it does not use ionizing radiation, MRI is frequently used in anatomical evaluation and in the detection of various pathologies (SOARES HAGE; IWASAKI, 2009; WESTBROOK; TALBOT, 2018).

The analysis of MRI images is performed using cutting planes such as axial, coronal and sagittal, as well as by evaluating T1 and T2 relaxation times. T1-weighted images highlight anatomical structures of soft tissues and high fat content, while the images T2-weighted images demonstrate the presence of fluids and specific pathologies, being useful for the identification of edema, tumors and inflammatory processes (BUSHBERG et al., 2012; KOCH; LI; MORITZ, 2021).

MRI has established itself as one of the most relevant imaging methods for diagnosis, but it still has limitations, such as acquisition time and image quality. In this context, tools based on artificial intelligence (AI) have stood out as alternatives to overcome these challenges, optimizing processes and increasing diagnostic accuracy (GORE, 2018; SHIN et al., 2020). Although this technology still faces obstacles, such as the simultaneous analysis of multiple abnormalities in different sections, evidence indicates that its clinical application has the potential to significantly improve diagnostic accuracy (RUITENBEEK et al., 2024).

The richness of detail provided by MRI is essential for clinical decision-making. However, contemporary radiology faces a confluence of challenges: the growth of number of exams, the complexity of visual information that requires increasingly more interpretations specialized and the need for greater efficiency in workflows (LEE et al., 2025). In this scenario, technological innovation is not just an option, but a requirement of clinical practice modern.

AI is defined as the science and engineering that seeks to simulate human behaviors with minimal human intervention. In medicine, this technology has stood out both in applications both virtual and physical. In the area of imaging exams, AI has been used to process large volumes of data from CT scans, MRIs and other diagnostic methods, identifying patterns, aiding in the early detection of diseases and improving the accuracy of medical reports. These solutions have contributed to faster, more personalized and accurate diagnoses. with a smaller margin of error, increasing the efficiency of health services and benefiting

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directly to patients (HAMET; TREMBLAY, 2017; ERICKSON et al., 2017).

The integration of AI into MRI imaging has resulted in faster exams and clearer images. clearer, bringing advantages especially for patients who experience discomfort during procedure. In addition, AI algorithms have been used to highlight suspicious areas in images, favoring the early detection of diseases such as brain tumors in children. Equally promising results were observed in musculoskeletal pathologies, such as bone tumors and joint conditions, offering more reliable diagnoses and reducing failures that could go unnoticed by human evaluation (BARROS et al., 2025; HADDADI AVVAL et al., 2025).

In view of this, this work gathered and analyzed studies that explore the use of artificial intelligence in magnetic resonance imaging, allowing the identification of the benefits and limitations of this technology. It was found that AI has contributed to more reliable diagnostic results, in addition to enabling the acquisition of faster and higher quality images, representing a relevant advance for practice radiological.

2. Material and Method

This work consists of an integrative literature review, a method described by Mendes et al. (2008) as a strategy that allows analyzing relevant research to support decision-making clinical decision and medical practice on a specific topic. This approach enables a broader understanding of the pathological phenomenon and the effects of the interventions evaluated in reviewed studies.

To prepare this work, the methodology proposed by Botelho et al. (2011) was adopted, structured in six stages: definition of the theme and research question, establishment of criteria inclusion and exclusion criteria, identification of pre-selected studies, categorization of studies chosen, analysis and interpretation of the results and, finally, presentation of the review. The search for literature references was conducted using Health Sciences Descriptors “Artificial Intelligence”, “Magnetic Resonance Imaging” and “Diagnostic Imaging”, combined with the Boolean operators AND and OR. The searches were conducted in the following databases: PubMed, MedLine, ACM Digital Library, SciELO and Google Scholar.
Regarding the inclusion criteria, studies published in the last ten years were selected, in English and Portuguese, of greater relevance and impact, aligned with the guiding question of this research. Included were papers that presented the original findings as well as updates and subsequent in-depth analysis, aiming to ensure accuracy and relevance.

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For the exclusion criteria, studies that were not directly related to the thematic, which presented uncertain or inconclusive results, which were obsolete or which were published in languages other than English or Portuguese.

3. Results and Discussion

According to the descriptors searched in the databases, 250 were found and analyzed articles and after careful reading and application of the inclusion and exclusion criteria resulted in 30 articles selected which are included in this integrative review (Table 1).

TABLE 1 – Articles used to structure the integrative review.

Origin	Article title	Journal title (volume, number and page)	Year	Language	Country of study
Pubmed	Applications of artificial intelligence and advanced imaging in pediatric diffuse midline glioma.	Neuro-Oncology (p. 1–15)	2025	English	USA
Portal of Periodicals	Intelligence artificial in the radiology: applications and impacts in magnetic resonance imaging and computed tomography.	Magazine Scientific Cleber Leite (v. 2, n. 1, p. 1-4)	2025	Portuguese	Brazil
PubMed	Artificial intelligence in medicine imaging.	Magnetic Resonance Imaging	2018	English	USA
SciELO	Image by resonance magnetic: basic principles.	Rural Science (v. 39, n. 4, p. 1287-1295)	2009	Portuguese	Brazilian
PubMed	Artificial intelligence in medicine.	Metabolism Clinical and Experimental (v. 69, p. S36–S40)	2017	English	USA
SciELO	Integrative review: method of research for the incorporation of evidence in health and nursing.	Text & Context Nursing (v. 17, n. 4, p. 758–764)	2008	Portuguese	Brazil
PubMed	Artificial intelligence in musculoskeletal imaging: realistic clinical applications in the next decade.	Skeletal radiology (v. 53, n. 9, p. 1849–1868)	2024	English	Netherlands

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PubMed	Clinical applications of artificial intelligence in radiology.	British Journal of Radiology (v. 96, n. 1150)	2022	English	United Kingdom
Springer	Promises of artificial intelligence in neuroradiology: a systematic technological review.	Neuroradiology (v. 62, n. 10, p. 1265-1278)	2020	English	Germany
ACM Digital Library	Generative adversarial networks.	Communications of the ACM (v. 63, n. 11, p. 139-144)	2020	English	USA
PubMed	Deep Learning to Simulate Contrast-Enhanced MRI for Evaluating Suspected Prostate Cancer.	Radiology (v. 314, n. 1, e240118)	2025	English	USA
ResearchGate / RSNA	Deep Learning in Neuroradiology: A Systematic Review of Current Algorithms and Approaches for the New Wave of Imaging Technology.	Radiology: Artificial Intelligence (v. 2, n. 2, e190026)	2020	English	USA
Publisher/Book	Explainable Artificial Intelligence in Medical Imaging: Fundamentals and Applications.	Book (Auerbach Publications)	2025	English	USA
PubMed	Clinical Application of Artificial Intelligence in Breast MRI.	Journal of the Korean Society of Radiology (v. 86, n. 2, p. 245-258)	2025	English	South Korea
MDPI	Enhancing Radiologist Productivity with Artificial Intelligence in Magnetic Resonance Imaging (MRI): A Narrative Review.	Diagnostics (v. 15, n. 9, 1146)	2025	English	Switzerland
PubMed	Use of an Artificial Intelligence System to Improve Radiologists' Performance in Differentiating Benign and Malignant Breast Lesions at DCE-MRI.	Radiology (v. 296, n. 3, p. 521-529)	2020	English	USA
Google Academic	Intelligence artificial in the magnetic resonance imaging: a bibliographic review about the applications and impacts on diagnostic imaging.	Repository Institutional of UTFPR - RIUT	2024	Portuguese	Brazil

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PubMed	Editorial for "Enabling AIÿ Generated Content for Gadolinium-Free Contrast-Enhanced Breast Magnetic Resonance Imaging".	Journal of Magnetic Resonance Imaging (v. 61, n. 3, p. 734-735)	2024 English	USA
Portal of Periodicals	Intelligence artificial in the magnetic resonance imaging: a bibliographic review about the applications and impacts on diagnostic imaging.	eduCAPES Portal	2024 Portuguese	Brazil
Frontiers	Ethical challenges of artificial intelligence in neuroradiology.	Frontiers in Radiology (v. 3, 1149461)	2023 English	Switzerland
Google Academic (CUNY)	Ethical Challenges of Artificial Intelligence in Neuroradiology.	CUNY Academic Works	2023 English	USA
Google Academic	Generative AI in Medicine Imaging: Applications, Challenges, and Ethics.	ResearchGate	2024 English	International
MDPI	Revolutionizing Cardiac Imaging: A Scoping Review of Artificial Intelligence in Echocardiography, CTA, and Cardiac MRI.	Cureus (v. 17, n. 1, e71314)	2025 English	USA
ScienceDirect	Advancing MRI reconstruction: a systematic review of deep learning and compressed sensing integration.	Biomedical Signal Processing and Control (v. 111, 108291)	2026 English	Netherlands
PubMed	Role of artificial intelligence in magnetic resonance imaging based detection of temporomandibular joint disorder: a systematic review.	British Journal of Oral and Maxillofacial Surgery (S0266-4356(24)00549-7)	2024 English	United Kingdom
ScienceDirect	Medical Imaging and Computational Image Analysis in COVID-19 Diagnosis: A Review.	Journal of Digital Imaging (v. 33, p. 1-13)	2020 English	USA
Springer	Healthcare and Artificial Intelligence.	Book/Monograph	2019 English	International (Book)
Nature	A critical assessment of artificial intelligence in magnetic resonance imaging of cancer.	npj Imaging (v. 3, n. 1, p. 1-12)	2025 English	United Kingdom

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Google academic	GAN review: Models and medical image fusion applications.	ResearchGate	2025	English	International (Revision)
European Journal	Artificial intelligence in radiology.	European Journal of Nuclear Medicine and Molecular Imaging (v. 51, p. 1-4)	2024	English	Germany

This Integrative Review demonstrates a robust consensus in the international literature on the role transformative of Artificial Intelligence (AI) in the field of Magnetic Resonance Imaging (MRI), with the publications focusing on the last decade, reflecting the rise of Deep Learning.
Deep Learning), a subfield of Machine Learning that uses neural networks with multiple layers. According to the summary presented in Table 1, the main findings revolve around three axes central: technical optimization and workflow acceleration, diagnostic improvement and reduction of risks, and ethical and methodological challenges.

3.1 Technical Optimization and Workflow Acceleration

There is clear agreement among the authors that AI is revolutionizing the operational efficiency of RM (BARROS et al., 2025; LEE et al., 2025). Works such as JO et al. (2020), for example, demonstrate that Deep Learning optimizes the image reconstruction process, a technique that combines with Compressed Sensing, to result in a drastically accelerates acquisition time. This capability not only improves the patient experience, reducing examination time, as well as increasing the processing capacity of the service image. Additionally, authors such as LEE et al. (2025) and RUITENBEEK et al. (2024) point out for the use of AI in automated triage and segmentation, freeing the radiologist to dedicate time to more complex cases. BARROS et al. (2025) reinforce that, even in the national context, Workflow optimization is the most immediate impact of AI.

3.2 Diagnostic Improvement and Risk Reduction

One of the biggest advances lies in AI's ability to increase diagnostic accuracy in exams volumetric and reduce the need for contrast. High accuracy is a dominant theme, especially in breast MRI (ZHU et al., 2019; KIM and HA, 2025) and neuroradiology (JO et al., 2020), where AI, through Deep Learning algorithms, can surpass or complement human performance in the characterization and classification of lesions (CÁRDENAS et al., 2022). MANN

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et al. (2020) clinically validated that the AI system significantly improved performance of radiologists in differentiating between benign and malignant breast lesions. This ability is extends to specific areas, such as the analysis of pediatric tumors (AVVAL et al., 2025), demonstrating the versatility of AI in automated segmentation.

Another crucial benefit is contrast reduction. The experimental study by HUANG et al. (2025) and the MORAN's editorial (2024) highlights that Generative AI can simulate images with contrast from non-contrast sequences. This innovation is essential to mitigate the risk of complications (such as nephrogenic systemic fibrosis) in patients with renal failure, minimizing the exposure to Gadolinium.

3.3 Challenges and the Ethical-Methodological Debate

While there is consensus on the potential of AI, authors disagree on the challenges of implementation. and ethical risks, which represent the main barriers. The main methodological divergence is in model validation. Although AI demonstrates high accuracy in specific datasets (CÁRDENAS et al., 2022), GORE (2018) criticizes the lack of prospective studies and the low generalization of algorithms, that is, the performance of a model trained in one center may drop drastically in a hospital with different equipment. AI's reliance on datasets robust is a limitation pointed out by multiple authors.

In the ethical field, PINKER et al.'s (2023) warning about the challenges in neuroradiology is replicated by other authors (HAMET and TREMBLAY, 2017): large-scale implementation must be preceded by resolving issues such as algorithmic bias, legal liability, and consent informed. The need for Explainable AI (XAI), highlighted by KHAN and SABA (2025), is essential so that the radiologist can understand and trust the algorithm's decision, mitigating the risk of decisions based on "black boxes".

In short, the literature converges in enthusiasm for AI's capabilities to optimize flow and improve diagnostic accuracy in MRI subspecialties. However, there is a strong call for the next research phase migrates from proof-of-concept studies to robust clinical trials and multicenter, with priority attention to ethical and regulatory structures.

Final Considerations

This review consistently demonstrates that artificial intelligence applied to magnetic resonance imaging presents solid technical potential, with clear advances in reconstruction and image acceleration, post-processing, and automated interpretation tasks. These gains

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technical findings are promising and suggest real possibilities for reducing examination time, improving quality of images and support for the detection of relevant findings; however, the translation of these results for proven clinical benefits is still limited by the predominantly retrospective and single-center of many studies (MENESES, nm; 2024; WU, c. et al.; 2025).

The main obstacles to clinical implementation are methodological and pragmatic: heterogeneity of metrics and protocols, lack of multicenter external validation and low representativeness of databases in relation to real populations. To overcome these barriers, coordinated research strategies are needed that prioritize prospective trials, repositories multicenter annotations and reporting standards that allow comparability and reproducibility of evidence (SANKAR, h. et al.; 2024; JO, t. et al.; 2020; CÁRDENAS, ce et al.; 2022).

The ethical, regulatory and equity dimensions require simultaneous attention to development technical. AI approaches, independent audits, data governance frameworks, and procedures for identifying and correcting biases are essential to avoid amplification of inequalities and to ensure transparency and accountability in clinical decisions supported by algorithms. In addition, compliance with regulatory requirements and protection of user privacy patient should be priorities on the path to safe adoption (PINKER, k. et al.; 2023; KHAN, air; 2025).

In practice, responsible adoption of AI in RM must follow a phased path: prioritize applications with strong technical evidence and low integration cost (e.g., reconstruction for reduction acquisition time; automated screening of critical findings), testing these solutions in studies controlled prospective and only then expand to more complex interpretative tasks. Therefore, technological integration must be accompanied by investments in infrastructure, training of professionals and continuous mechanisms for monitoring post-performance implementation to detect drift and preserve clinical safety (MANN, rm et al.; 2020; LEE, j. h. et al.; 2025).

In short, AI in MRI has real potential to transform technical aspects and operational aspects of radiological practice, but its promise will only be fully realized if it is accompanied by robust clinical validation, ethical governance, methodological standardization and efforts sustainable implementation strategies. The convergence between researchers, clinicians, regulators, and managers health will be crucial to converting current technical progress into lasting benefits for patients and health systems. (MENESES, 2024; WU et al., 2025)

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