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Use of magnetic resonance imaging as a non-invasive method in the diagnosis of cervical carcinoma: a systematic review

Use of magnetic resonance imaging as a non-invasive method in the diagnosis of cervical carcinoma: a systematic review

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Summary

Cervical cancer is, in most cases, related to infection with the Human Papillomavirus (HPV). Persistent infections with certain types of HPV may be associated with the development of cancer from cellular alterations in the cervix. Magnetic resonance imaging (MRI) is a non-invasive imaging method that has been used primarily for internal medicine evaluation. This study aims to highlight the importance of MRI in the diagnosis of cervical cancer, as a non-invasive technique for early detection, staging, and monitoring of the disease. This systematic review uses databases such as the National Library of Medicine (PubMed) and the Scientific Electronic Library Online (Scielo), using the keywords: "Cervical Neoplasms," "Cervical Dysplasia," "Cervical Dysplasia," and "Cervical Intraepithelial Neoplasms."

"Magnetic Resonance Imaging." Studies from the last five years were included, and articles that did not mention magnetic resonance imaging were excluded. This review is expected to highlight the importance of using MRI in the early diagnosis of cervical cancer as a non-invasive method, as well as encourage its use in disease monitoring, improving patient prognosis.

Keywords: Cervical Cancer, Cervical Intraepithelial Neoplasias, Female Genital Tract Neoplasias, Women's Health, Neoplasia Staging, Diagnostic Imaging.

Abstract

Cervical cancer is, in most cases, related to infection with the Human Papillomavirus (HPV). Persistent infections with certain types of HPV may be associated with the development of cancer from cellular changes in the cervix. Magnetic resonance imaging (MRI) is a noninvasive imaging method primarily used for internal medicine evaluation. This study aims to highlight the importance of MRI in the diagnosis of cervical cancer as a noninvasive technique for early detection, staging, and monitoring of the disease. This systematic review used databases such as the National Library of Medicine (PubMed) and the Scientific Electronic Library Online (Scielo) and used the keywords "Cervical Neoplasms," "Cervical Dysplasia," "Uterine Cervical Dysplasia," "Cervical Intraepithelial Neoplasms" and "magnetic resonance". Studies published in the last five years were included, and articles that did not mention magnetic resonance imaging were excluded. This review is expected to highlight the importance of using MRI in the early diagnosis of cervical cancer as a noninvasive method, as well as encouraging its use in disease monitoring, improving patient prognosis.

Keywords: Cervical Cancer, Cervical Intraepithelial Neoplasms, Female Genital Tract Neoplasms, Women's Health, Neoplasm Staging, Diagnostic Imaging.

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1. Introduction

Magnetic Resonance Imaging (MRI) is a non-invasive imaging method used primarily for internal medicine evaluation that has demonstrated great relevance in the diagnosis of various pathologies, as well as in the staging of cervical cancer. In addition, this method presents among its main advantages, the absence of ionizing radiation and the high quality of the acquired images (SANTOS, 2007).

The rotating magnetic field was first reported in 1882 by Nikola Tesla, and in 1937, Isidor Rabi, a physics professor, developed a method to measure the movements of nuclei atomic and in 1946, the first experiment involving MRI was carried out in the laboratories of physicists Felix Bloch and Edward Purcell. They concluded that some nuclei, when placed in magnetic fields, absorbed energy within a radiofrequency range of the spectrum electromagnetic, forming the image (FERREIRA et al., 2005).

The basic principle of MRI is related to the behavior of hydrogen nuclei that when subjected to an intense magnetic field they undergo alignment, and are subsequently excited by radiofrequency waves. The nuclei, upon returning to their original state, released signals, these signals are captured by antennas known as coils, which are responsible for transmit a magnetic flux in the region of interest, enabling the capture of the image that will be processed by computational algorithms, generating three-dimensional images of the organs and internal structures (FERREIRA et al., 2005).

It should be noted that in MRI there are considerations regarding the way in which the images are formed, depending on the relaxation characteristics of the tissues classified as T1 and T2 (MAFRAJI, 2023). In T1 weighting, the image is similar to the appearance of real anatomy, showing the fat in light color and the fluids in dark color, being ideal for confirming masses that contain fat. In the T2 sequence, the cerebrospinal fluid shines, highlighting structures such as ventricles, sulci and cistern; in this case, both fats and fluids appear clear, the which is particularly useful for identifying tumors, inflammations and traumas (VIEIRA, 2023).

This ability to differentiate tissues and highlight structural changes gives MRI a role essential in oncology, especially in the study of pelvic neoplasms such as cervical cancer, since it allows for an accurate assessment of injuries, their staging and even detection early detection of relapses, fundamental aspects for therapeutic planning (CHEN; KITZING; LO, 2024).

MRI, through its pulse sequences and different weightings, stands out as one of the most advanced diagnostic tools in the field of oncology, with emphasis on cancers in the pelvic region, such as cervical cancer. The technique provides high-resolution images that

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allow an accurate assessment of pelvic structures, and allows early detection of recurrence essential for formulating effective treatment strategies, especially in complex conditions (SANTOS et al., 2007).

Several types of neoplasms can affect the female reproductive system, including highlight cancers of the ovary, endometrium, vulva, vagina and, above all, cervix, considered the fourth most common among women in the world and the third in Brazil. For each year for the 2023-2025 triennium, 17,010 new cases were estimated in Brazil, which represents a rate gross incidence of 15.38 cases per 100,000 women (ABDUL-LATIF et al 2023).

Cervical cancer is, in most cases, associated with persistent infection by Human Papillomavirus (HPV), which causes cellular changes in the cervix and can progress undetected in the absence of preventive exams, such as the Pap smear. Among the main Symptoms include abnormal vaginal bleeding, pelvic pain or pain during intercourse, and changes in urinary (SANTOS; SILVA; OLIVEIRA, 2022).

Therefore, since imaging methods are non-invasive techniques and are increasingly being most used as a form of diagnosis, this research seeks to highlight the importance of MRI for the diagnosis of uterine cancer, in order to alert and raise awareness among the population about a extremely important topic, and often little discussed.

2. Material and Method

This work was a systematic review study. Databases were used such as the National Library of Medicine (PubMed), Scientific Electronic Library Online (Scielo) and Latin American and Caribbean Literature in Health Sciences (Lilacs) using the following descriptors: “Neoplasms of the Cervix”, “Cervical Intraepithelial Neoplasms”, “Neoplasms of the Female Genital Tract”, “Women’s Health”, “Staging of Neoplasms”, “Diagnosis by Image”, “Magnetic Resonance”. National and international works were included last 5 years (2020-2025), which mention MRI and cervical cancer, in the languages Portuguese, English and Spanish. Works that did not mention RM and that mentioned other types of cancer, other than those of the uterus. Data analysis was qualitative and descriptive, organized in tabular form, seeking to identify the main challenges and future perspectives of the application of MRI for medical diagnosis.

3. Results and Discussion

According to the descriptors searched in the databases, 27 were found and analyzed

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articles, and after careful reading and application of the inclusion and exclusion criteria, 13 were found.

selected articles which comprise this review.

Table 1: studies selected according to the theme proposed to compose the present research.

Origin Title of Work		Journal title (Volume, number and page)	Year	Language	Country of study
PubMed	Interobserver agreement of transvaginal ultrasound and MRI in local staging of cervical cancer	Ultrasound in Obstetrics & Gynecology, volume 58, number 5, pages 773-779 (Nov 2021)	2021	English	Italy
PubMed	MRI and ultrasound examination in preoperative pelvic staging of early-stage cervical cancer: post-hoc SENTIX study	Ultrasound in Obstetrics & Gynecology, vol.65, no.4, pp. 495–502	2025	English	Multicenter
PubMed	360° 3-D Transvaginal Ultrasound vs. MRI for Assessment of Vaginal Invasion in Cervical Cancer	Ultrasound in medicine & Biology, vol. 47, no. 8, p. 2250–2257 (Aug 2021).	2021	English	Italy
PubMed	Functional Magnetic Resonance Imaging in Cervical Cancer Diagnosis and Treatment	Clinical Oncology, volume 35, number 7, pages 433–441 (2023).	2023/2024	English	China
PubMed	2018 FIGO Staging Classification for Cervical Cancer: Added Benefits of Imaging	RadioGraphics, volume 40, number 6, pages 1807–1822 (2020).	2020	English	Australia
PubMed	Comparison of contrast-enhanced ultrasonography and MRI in evaluation of tumor size and local invasion	Abdominal Radiology (New York), volume 47, number 8, pages 2928–2936, in August 2022.	2022	English	China

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PubMed	Multimodal MRI in the diagnosis of cervical cancer and its correlation with differentiation process	BMC Medical Imaging, Volume 23, Number 1, Article 144, September 29, 2023	2023	English	China
PubMed	MRI features of tumor and lymph node to predict clinical outcome in node-positive cervical cancer	European Radiology, volume 30, number 5, pages 2851–2859, in May 2020.	2020	English	China
PubMed	Diagnosis of Early Cervical Cancer with a Multimodal MRI under AI Algorithm	Average Contrast & Molecular Imaging, March 23, 2022	2022	English	China
PubMed	Radiomic Features of T2-weighted Imaging and Diffusion Kurtosis Imaging in Differentiating Clinicopathological Characteristics of Cervical Carcinoma	Journal of Magnetic Resonance Imaging, volume 54, number 3, pages 904–914, in September 2021.	2021	English	China
PubMed	EMPIRIC: exploratory study using MR prognostic imaging markers for radiotherapy in cervix cancer (protocol)	Radiotherapy and Oncology, volume 168, article 107–108, in 2022.	2024	English	United Kingdom / Multicenter
PubMed	Diffusion-weighted imaging in the assessment of cervical cancer: reduced FOV vs conventional	Minutes Radiologica, volume 64, number 8, pages 2485–2491, in August 2023	2024	English	China

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SciELO Brazil	Magnetic resonance imaging in the staging of cervical tumors.	Brazilian Journal of Radiology and Diagnostic Imaging, volume 80, number 6, pages 383–389, in 2017.	2007	Brazilian Portuguese	
MDPI AG. Systematic Review — Role of MRI in Cervical Cancer Staging		Cancers, volume 16, number 11, page 1983.	2024	English	USA

Source: own authorship, (2025).

According to the selected studies, Magnetic Resonance Imaging (MRI) has been consolidated as one of the most relevant tools in the detection, staging and monitoring of breast cancer cervix, representing a milestone in the evolution of imaging diagnosis in gynecology oncology. Technological advancements in equipment, improvements in pulse sequences, and incorporation of artificial intelligence algorithms has allowed MRI to become a method non-invasive and sensitive, capable of providing morphological and functional information about the tumor, with a direct impact on the therapeutic conduct and prognosis of patients (Chen et al., 2024).

According to Santos et al. (2007), MRI is of great relevance in the staging of cervical tumors. uterine in the national context, highlighting the superiority of this method in differentiating soft tissues and in assessing the local extent of disease, especially in comparison to ultrasound and computed tomography (CT). These findings parallel those of results of Del Frate et al. (2021), who, in a comparative analysis between MRI and three-dimensional transvaginal ultrasonography (3D-TVUS), observed high agreement interobserver reliability between the methods, but reinforced that MRI presents greater accuracy in detecting of parametrial and vaginal invasion, critical parameters for correct staging according to the FIGO 2018 classification.

This integration was reinforced by Pavlidis et al. (2020), who highlighted the benefits of RM and PET/CT in the identification of metastatic lymph nodes and in the redefinition of clinical stages previously determined only by physical examination. In a complementary context, Zhang et al. (2022) explored the application of artificial intelligence (AI) and multimodal image analysis in

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MRI for the early diagnosis of cervical cancer. The study showed that MRI algorithms learning can detect subtle changes in tumor tissue, achieving sensitivity above of 90%. This trend was also confirmed by Liu et al. (2022), who developed a network Convolutional neural network (CNN) for automatic segmentation of target volume in patient MRI with cervical cancer, reducing radiotherapy planning time and increasing the reproducibility of results.

Research such as that by Xu et al. (2021) and Liu et al. (2023) demonstrates that parameters derived from Diffusion-weighted (DWI) and perfusion-weighted (DCE-MRI) sequences can predict tumor recurrence and grade of histological differentiation, making MRI not only a diagnostic tool, but also prognostic. Such findings are especially important in patients with advanced disease or undergoing conservative treatment, as they allow early identification of failure patterns therapeutic and adjust the treatment in a personalized way.

In the Asian scenario, studies from China according to Huang et al. (2023) and Chen et al. (2022) have contributed significantly to the understanding of the application of MRI in breast cancer cervix. These studies reinforce that, in addition to high anatomical resolution, MRI can differentiate neoplastic tissues from areas of inflammation or necrosis, which reduces the risk of false-positive diagnoses and improves staging accuracy.

In parallel, Zhou et al. (2023) identified that variations in apparent diffusion coefficients sequence (ADC) of MRI during post-treatment follow-up are strongly associated with tumor recurrence within two years, suggesting that the routine use of diffusion MRI may be essential for monitoring. Additionally, the EMPIRIC (2024) study developed in the United Kingdom Unido introduces a new perspective on the use of MRI imaging biomarkers to predict response to radiotherapy, marking a transition from purely anatomical diagnosis for a predictive imaging model. This trend aligns with the current movement in oncology precision, in which the role of MRI goes beyond simple tumor detection, becoming an element-key to guiding individualized therapies.

In Brazil, although the availability of RM is limited in some regions, its implementation in reference centers has demonstrated a positive impact on reducing morbidity and mortality and improving patient prognosis. According to INCA estimates (2023), breast cancer cervix remains among the main causes of death from neoplasia among Brazilian women, which reinforces the need for integrated screening strategies, early diagnosis and post-treatment follow-up, in which MRI plays a strategic role.

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Final Considerations

The results of this review reinforce that magnetic resonance imaging (MRI) is a useful tool essential in all phases of cervical cancer management, ranging from diagnosis and initial staging until therapeutic monitoring and detection of relapses. In addition to consolidating its role as the most accurate and comprehensive imaging method, this study highlights the need to promote new research that explores the potential of MRI in more accurate diagnostic and therapeutic protocols, contributing to the improvement of clinical strategies and to improve the outcomes of patients with this neoplasm.

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