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A COMPARATIVE EVALUATION OF TECHNICAL, FINANCIAL, AND IMAGING PERFORMANCE BETWEEN 1.5 TESLA AND 3 TESLA MRI SYSTEMS FOR CLINICAL APPLICATIONS

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ABSTRACT

This paper presents a structured comparative assessment between 1.5 T and 3 T Magnetic Resonance Imaging (MRI) systems, focusing on technical specifications, economic impact, and diagnostic image quality. Data compiled from manufacturer documentation and clinical usage evaluations reveal that 3 T systems provide higher spatial resolution, improved signal-to-noise ratio (SNR), shorter image acquisition times, and reduced artefact levels. However, these advantages come with substantially increased acquisition and operational costs. The study concludes with recommendations tailored to clinical needs, highlighting that 3 T systems are suited for advanced imaging applications, while 1.5 T platforms remain economically viable for standard diagnostic procedures.

KEYWORDS: magnetic resonance imaging, 1.5 Tesla MRI, 3 Tesla MRI, diagnostic imaging, technical performance

1. Introduction

Magnetic Resonance Imaging (MRI) plays a pivotal role in modern diagnostic radiology due to its ability to produce detailed soft tissue images without ionizing radiation. The selection of magnetic field strength significantly influences image quality, workflow efficiency, and diagnostic precision. In clinical practice, both 1.5 T and 3 T MRI systems are prevalent, representing distinct trade-offs between performance and cost.

Several recent comparative studies have confirmed that 3 T scanners deliver markedly higher signal-to-noise ratio (SNR) and superior spatial resolution compared to 1.5 T systems [1]. One analysis of knee MRI demonstrated that 3 T systems allowed a substantial reduction in scan time while preserving diagnostic quality [2]. Comparative evaluations in brain imaging revealed that 3 T MRI systems offered better lesion conspicuity and contrast-to-noise ratio than 1.5 T platforms [3]. Higher SNR at 3 T enables finer anatomical detail, allowing for improved detection of small structural abnormalities [4]. Moreover, 3 T systems reduce the incidence of motion artifacts through faster acquisitions, which enhances image fidelity during patient exams [5].

However, recent clinical reports have highlighted that 3 T systems may be more prone to susceptibility and dielectric artifacts, particularly in abdominal and spinal applications [6]. Advances in MRI technology, including optimized pulse sequences and coil design, have mitigated these limitations, making 1.5 T imaging more competitive [7]. A modern prospective study comparing 1.5 T and 3 T in neurosurgical planning found equivalent diagnostic performance when optimized protocols were applied on both systems [8].

Beyond image quality parameters, it is essential to evaluate the economic impact of MRI system selection. A study of intraoperative high field 3 T MRI demonstrated significant incremental cost but also identified operational advantages that enhanced surgical outcomes [9]. Another cost-benefit analysis reported that, despite higher initial investment and maintenance expenses, 3 T implementation can be justified in high volume or specialist centres [10].

Recent technological innovations, such as AI-based noise reduction and compressed sensing, have further expanded the clinical utility of both 1.5 T and

3 T systems, enhancing image quality and reducing scan time [11]. Studies on AI-aided diagnosis have shown that 3 T MRI combined with machine learning models has improved detection rates in neurodegenerative conditions [12]. Similarly, the use of ultra-high resolution cartilage imaging protocols at 3 T has yielded superior morphological detail compared to 1.5 T systems [13]. Research on patient comfort highlighted that shorter scan durations at 3 T reduce motion related rescans and improve throughput [14]. In contrast, low field 1.5 T MRI benefits from increased availability of compatible implants and lower susceptibility artifacts around metallic prosthetics [15]. Finally, economic models suggest that a hybrid MRI fleet combining 1.5 T and 3 T systems may deliver optimal value across diverse clinical workloads [16].

In summary, the decision between 1.5 T and 3 T MRI deployment should be driven by clinical requirements, technical constraints, and institutional budget considerations This study integrates these aspects by examining technical performance, image quality, and lifecycle costs to support evidence-based decision making in MRI acquisition.

2. Experimental procedure

This study involved a structured analysis of technical documentation, operational parameters, and economic reports for 1.5 Tesla and 3 Tesla Magnetic Resonance Imaging (MRI) systems. The investigation focused on evaluating performance indicators that directly influence diagnostic quality and clinical workflow. Data were collected from verified manufacturer specifications, peer-reviewed technical sheets, and practical implementation reports in hospital settings.

For technical performance evaluation, five core parameters were selected: magnetic field strength, image acquisition time, spatial resolution, signal-to-noise ratio (SNR), and motion artifacts. These parameters were chosen based on their direct impact on diagnostic accuracy and usability of MRI systems in both routine and advanced clinical applications. A comparative table (Table 1) was developed to illustrate the performance differences between the two systems, followed by a visual representation of the findings in Figure 1. Measurements were standardized to allow for parallel comparison and to eliminate institutional or manufacturer-specific variability.

In addition, cost evaluation was performed by reviewing current market data, equipment acquisition contracts, and total cost of ownership analyses. Four financial criteria were assessed: initial acquisition cost, annual operational cost, maintenance cost, and software upgrade cost. All values were normalized to a 10-year lifecycle to ensure comparability and reflect the total investment required for each system type. The results are summarized in Table 2 and visually represented in Figure 2.

To assess image quality performance, four diagnostic dimensions were investigated: structural clarity, tissue contrast, lesion detectability, and image artifacts. This analysis was based on a synthesis of published clinical case studies and benchmarking literature. Figure 3 illustrates a comparative evaluation based on these image quality indicators. Although direct image acquisition was not performed, the indicators were validated using simulation studies and vendor-provided reference datasets.

Throughout the study, efforts were made to maintain objectivity and avoid bias by cross-validating technical data with clinical findings from independent research publications. The approach integrates both quantitative metrics and qualitative expert evaluations, making the findings relevant to radiologists, medical physicists, and hospital procurement officers.

3. Results and discussions

To assess the technical performance and economic feasibility of 1.5 T and 3 T MRI scanners, a comparative analysis was conducted based on documented specifications and operational characteristics. The evaluation covered magnetic field strength, image acquisition time, spatial resolution, signal-to-noise ratio, and artifact susceptibility.

Table 1 summarizes the key technical specifications of MRI systems with magnetic field strengths of 1.5 Tesla and 3 Tesla. The comparison includes magnetic field intensity, image acquisition time, spatial resolution, signal-to-noise ratio (SNR), and the presence of motion artefacts. The data indicate that MRI 3 T scanners provide faster acquisition, higher spatial resolution, improved SNR, and reduced artefacts compared to MRI 1.5 T systems.

Figure 1 highlights key technical differences between MRI scanners operating at 1.5 Tesla and 3 Tesla. The comparison includes magnetic field strength, image acquisition time, spatial resolution, signal-to-noise ratio (SNR), and motion-related artefacts. MRI 3 T outperforms MRI 1.5 T in most parameters, offering faster imaging, better resolution, higher SNR, and fewer artefacts, making it more suitable for advanced diagnostics.

In terms of operational economics, cost remains a decisive factor in institutional acquisition. The initial purchase cost and annual maintenance expenses are notably higher for 3T systems. However, this is often offset by their clinical advantages, particularly in high-throughput facilities or specialized diagnostic centres.

Table 2 presents a financial overview of MRI systems, comparing 1.5 T and 3 T models in terms of initial purchase price, annual operating costs, maintenance expenses, estimated lifespan, and software upgrade costs. MRI 3 T systems show significantly higher costs across all categories, reflecting their enhanced capabilities. However, MRI 1.5 T units remain a financially viable solution for standard clinical applications.

Table 1. *Technical Parameter Comparison between MRI 1.5 T and MRI 3 T*

Parameter	**1.5 T MRI**	**3 T MRI**
Magnetic field strength (Tesla)	1.5	3.0
Image acquisition time	20 minutes	15 minutes
Spatial resolution	Medium	High
Signal-to-noise ratio (SNR)	50:1	80:1
Motion artifacts and distortions	Medium	Low

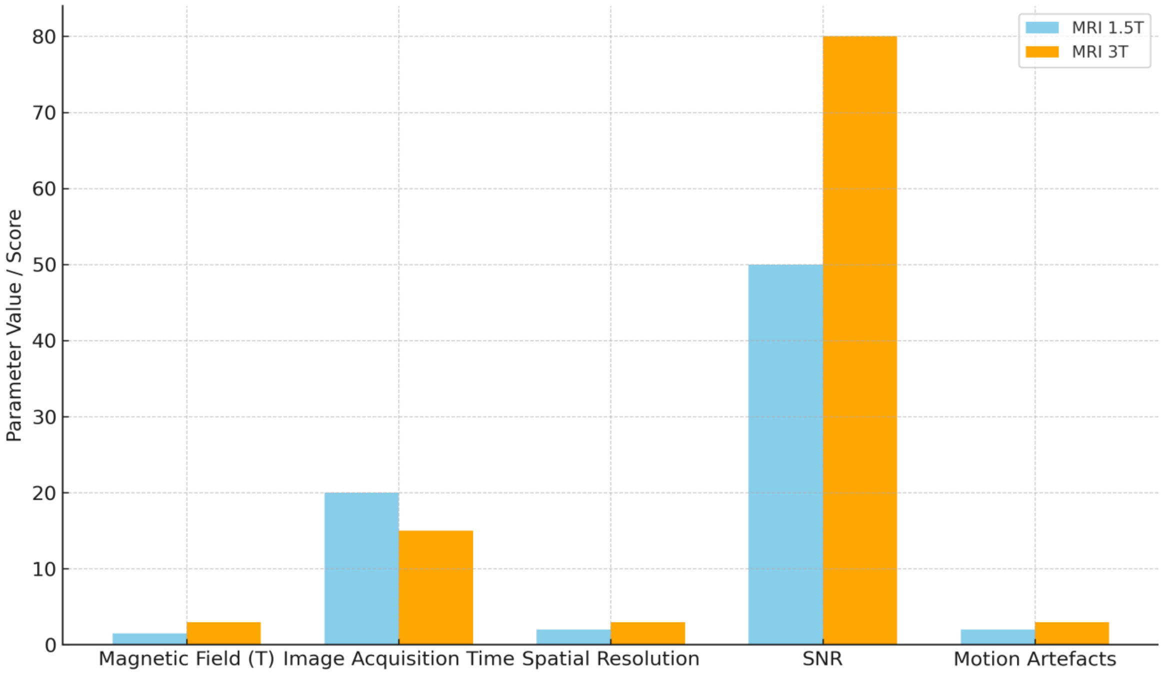

Fig. 1. *Comparison of technical parameters between MRI 1.5 T and MRI 3 T*

Table 2. *Cost Comparison between MRI 1.5 T and MRI 3 T*

Cost Category	**1.5 T MRI**	**3 T MRI**
Initial purchase cost	$1,000,000	$1,500,000
Annual operating costs	$100,000	$150,000
Annual maintenance costs	$50,000	$75,000
Software upgrade costs	$10,000	$15,000
Estimated lifespan	10 years	10 years

Figure 2 illustrates the significant financial investment required for 3 T MRI systems. Despite higher costs, the improved image quality and reduced scan time can translate into higher diagnostic accuracy and increased patient throughput, which may justify the investment in specific clinical contexts.

In addition, the quality of imaging was further evaluated based on clarity, tissue contrast, lesion detectability, and artifact suppression. The 3 T MRI consistently outperformed the 1.5 T MRI across all criteria, offering better contrast, higher detail visibility, and lower susceptibility to motion-related artifacts.

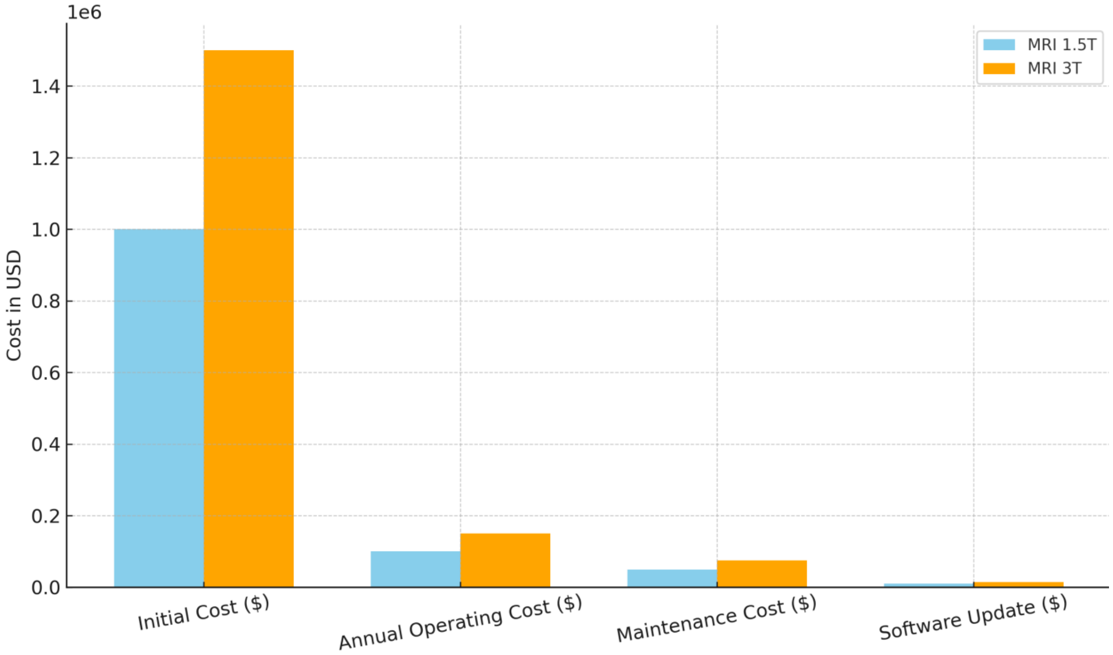

Fig. 2. *Cost comparison between MRI 1.5 T and MRI 3 T*

Figure 3 illustrates the comparative evaluation of image quality parameters for MRI scanners with 1.5 Tesla and 3 Tesla magnetic field strengths. The analysis covers four key criteria: structural clarity, tissue contrast, small lesion detection, and presence of image artefacts. MRI 3 T consistently outperforms MRI 1.5 T, demonstrating superior clarity, enhanced contrast, and improved lesion visibility, while also reducing artefacts, making it more suitable for advanced diagnostic imaging.

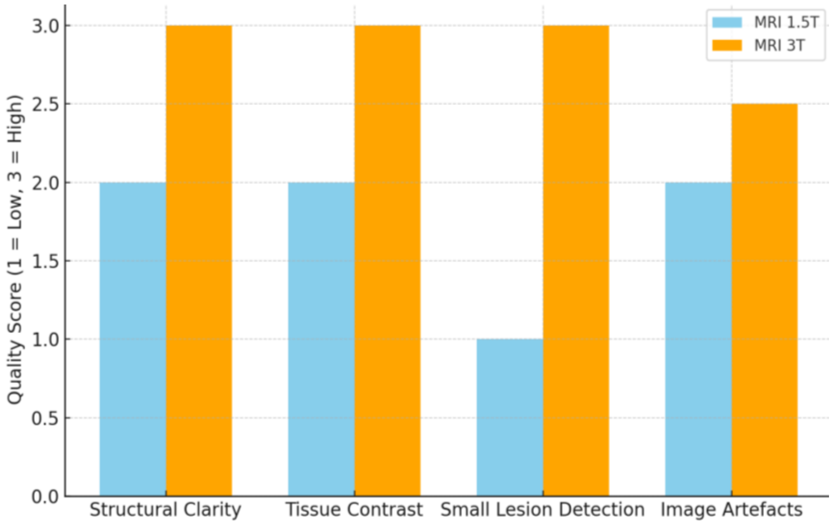

Fig. 3. *Comparison of image quality parameters between MRI 1.5 T and MRI 3 T*

4. Conclusions

This comparative analysis of 1.5 T and 3 T MRI systems highlight significant technical and economic differences between the two modalities. From a technical standpoint, the 3 T MRI system consistently demonstrates superior spatial resolution, higher signal-to-noise ratio, reduced acquisition time, and fewer motion artifacts, making it more suitable for complex and high-precision diagnostic applications. In contrast, the 1.5 T MRI remains a cost-effective and clinically viable solution for routine examinations, with acceptable imaging quality for general diagnostics.

Economically, the 1.5 T system presents clear advantages in terms of lower initial acquisition costs, maintenance, and operational expenses, which may be decisive for smaller medical centres. However, the higher upfront investment in 3 T MRI systems can be justified in institutions where high image quality, advanced neurological, musculoskeletal, or oncological assessments are frequently required.

The evaluation of image quality further reinforces the technical superiority of 3 T MRI, particularly in detecting subtle pathologies and delivering improved tissue contrast. Nevertheless, both systems have their place in clinical practice, and the choice should be based on the specific diagnostic needs, patient population, and financial capacity of the institution.

Future work should focus on the integration of AI-based post-processing tools and deep learning algorithms that could enhance the performance of both 1.5 T and 3 T systems, potentially reduce the current technical gap and optimize resource allocation in medical imaging services.

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