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Review Article

Statistical Data Analysis of Signal-to-Noise Ratio in MRI and CT Scans

***[a]Joseph Ozigis Akomodi, [b]Maddisyn Neita, [c]Samia Ahmed, [d]Aiyana Parnell and [e]Aaliyah Taylor**

[a]Department of Education, Long Island University, New York, USA
[b,c&d]Queens Gateway to Health and Sciences, New York City, USA
[e]University of Alabama, USA
*Corresponding Author Email: jakomod@gmail.com

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Abstract
The main focus of this study is to ascertain the differences between computed tomography and magnetic resonance imaging with respect to their signal-to-noise ratio (SNR) to optimize their diagnostic imaging. Owing to the significance of SNR in establishing image clarity and accuracy of diagnosis, the study is interested in investigating a practical dataset to understand SNR levels across the two imaging technologies and appreciate the potential of imaging factors in place to acquire time or slice thickness on such ratios. The study establishes that compared to CT, MRI obtains considerably higher SNR levels, which depicts variances between modalities in imaging professionalism and data gathering approaches. Therefore, there is practical significance in optimizing imaging protocols to augment diagnostic confidence and ultimately improve patient well-being. The research discussed the significance of varying parameters in contemporary diagnostic imaging and how such variables influence Imaging SNR, including those such as observation and technical challenges. There is an emphasis on the importance of the study in enlightening imaging technicians and radiologists regarding adapting their practices by establishing higher variables which impact image outcomes directly to the patient. Although higher variables cannot be referred to as a panacea, the study determines the potential use of such research in guiding greater quality improvement in diagnostic imaging, which considerably impacts hospital service quality and ultimately patient wellness.
Keywords: MRI Scans, CT Scans, Signal-to-Noise Ratio (SNR).

Introduction

Medical imaging plays a critical role in diagnostic medicine by providing non-invasive, high-resolution visualization of internal anatomical structures and pathological diseases. Among the most commonly utilized imaging modalities are magnetic resonance imaging (MRI) and computed tomography (CT), each offering distinct advantages based on their underlying physical principles and imaging capabilities. MRI is a non-ionizing imaging modality that uses a combination of strong magnetic fields, radiofrequency pulses, and gradient coils to generate comprehensive anatomical images. The method exploits the magnetic properties of hydrogen protons, which are abundant in water and fat throughout the human body (Berger, 2002), and when exposed to a magnetic field, these protons align with the field and are then perturbed by a radiofrequency pulse. As the protons return to equilibrium, they emit signals that are spatially encoded and mathematically reconstructed into high-resolution images (Grover *et al.,* 2015; Iqbal *et al.,* 2023).

MRI is highly regarded for its soft tissue contrast, making it ideal for imaging the brain, spinal cord, joints, muscles, and internal organs (Iqbal *et al.,* 2023). It provides an extensive array of imaging sequences that can be tailored to emphasize certain tissue characteristics, fluid content, or pathological changes. However, MRI scans typically have higher acquisition times and are more sensitive to motion artifacts than other imaging modalities (Iqbal *et al.,* 2023), thus insinuating implications such as reduced patient comfort and lowered cost-effectiveness.

CT is an imaging technique based on ionizing radiation, specifically X-rays, to create cross-sectional images of the body. During a CT scan, an X-ray tube rotates around the patient, capturing numerous projections from different angles. These projections are processed using computational algorithms to reconstruct detailed tomographic slices (Patel *et al.,* 2023). CT is recognized for its speed, availability, and ability to capture high-resolution images of dense structures such as bones, the lungs, and blood vessels. It is particularly useful in emergency settings due to its rapid acquisition time. However, because CT involves exposure to ionizing radiation, its use must be carefully balanced against the diagnostic benefits, especially in populations requiring repeated imaging (Iqbal *et al.,* 2023).

Definition and Significance of Signal-to-Noise Ratio in Medical Imaging

A fundamental metric used to assess image quality in both modalities is the signal-to-noise ratio (SNR), which has a significant effect on diagnostic accuracy. In medical imaging, the signal-to-noise ratio (SNR) is a critical metric used to evaluate image quality, defined as the ratio between the true anatomical signal and the background noise. A higher SNR typically corresponds to a clearer, more diagnostically useful image, allowing for better visualization of structures and reducing the likelihood of diagnostic error, while a lower SNR is grainy and possesses the potential to obscure findings (Wu, 2025). The optimization SNR is of utmost importance due to its direct impact on image quality and diagnostic accuracy. Various noise sources affect both magnetic resonance imaging (MRI) and computed tomography (CT), including electronic interference, magnetic field inhomogeneities, thermal fluctuations, and patient-related factors like movement (Kwok, 2024). As a result, extensive research is continuously being conducted to enhance SNR through both algorithmic and hardware innovations.

On the algorithmic front, advances in image reconstruction techniques have yielded encouraging results. One being with the use of Fourier-based reconstruction algorithms. It was found that Fourier-based reconstruction can significantly improve SNR in MRI by selectively suppressing high-frequency noise while retaining essential image structures (Wu, 2025). Such computational methods are being investigated in both MRI and CT to mitigate the negative effects of short acquisition times and motion artifacts, thus contributing to more diagnostically reliable and clear images. In parallel, hardware-based approaches have gained notoriety for their potential to augment signal detection capabilities. For example, frequency-selective B1 field-focusing passive Lenz resonators designed for MRI applications have been introduced to improve SNR by concentrating the radiofrequency magnetic field within a specific imaging volume, enhancing signal reception without requiring active power sources (Hodgson *et al.,* 2024). Innovations like these stress the importance of engineering solutions in both MRI and CT system design, especially in clinical scenarios demanding high-resolution imaging under low-signal conditions. Overall, SNR maximization is vital in both MRI and CT imaging as it has a direct impact on image clarity, accuracy, and diagnostic reliability. Improving SNR, whether through advanced reconstruction algorithms or the integration of novel hardware solutions, contributes to more efficient imaging workflows and improved patient outcomes (Hodgson *et al.,* 2024; Wu, 2025).

Comparison of Challenges Between MRI and CT Regarding SNR

Though signal-to-noise ratio (SNR) is a significant determinant of image quality in medical imaging and directly influences diagnostic accuracy, both magnetic resonance imaging (MRI) and computed tomography (CT) face unique challenges when it comes to maximizing SNR, owing to their distinct imaging principles and technical constraints. Magnetic resonance imaging (MRI) faces several intrinsic challenges in optimizing signal-to-noise ratio (SNR) mainly due to its reliance on radiofrequency signal acquisition from hydrogen nuclei within tissue. One of the primary limitations of MRI is the inherent low signal strength that results from the weak electromagnetic signals generated by hydrogen nuclei during tissue excitation, which long acquisition times, magnetic field inhomogeneities, and patient motion can further compromise (Ali *et al.,* 2013; Adam and Ahmed, 2020; Parsa *et al.,* 2023). These factors collectively reduce image clarity and diagnostic reliability, in turn affecting the SNR. Despite this, studies show MRI demonstrates a higher average sensitivity (92.5%) and slightly greater specificity (89.7%) when detecting skull base ENT pathologies compared to CT, reflecting its ability to capture soft tissue variations (Iqbal *et al.,* 2023).

In contrast, computed tomography (CT) presents a different set of challenges regarding SNR, primarily related to its dependence on X-ray photon interactions. CT imaging is more robust to some forms of motion artifact due to faster acquisition speeds, but its SNR is closely tied to radiation dose levels (Sadia *et al.,* 2024). Lowering the dose to reduce patient exposure often leads to increased image noise, particularly due to reduced photon counts and statistical fluctuations in detector readings. Detector limitations and electronic noise also influence CT performance, particularly when high image resolution is required under low-dose protocols (Mourad *et al.,* 2024). Despite these challenges, CT remains valuable for evaluating bony anatomy, with a mean sensitivity and specificity of 84.4% each in detecting skull base ENT conditions (Iqbal *et al.,* 2023). Iterative reconstruction algorithms are commonly employed in CT to mitigate noise post-acquisition, enhancing image clarity without compromising safety.

Purpose and Hypothesis

The purpose of this study is to use statistical methods to analyze and compare signal-to-noise ratios (SNRs) in magnetic resonance imaging (MRI) and computed tomography (CT) scans to gain a better understanding of how image quality differs between two widely used imaging modalities. The study aims to determine which modality performs better under various clinical situations, which will include the scans of bones, organs, and soft tissue. The research will respond to the following question: *How do the signal-to-noise ratios in MRI and CT scans compare in terms of diagnostic image quality and consistency?* It is hypothesized that MRI will have much higher SNR values than CT due to its improved soft tissue contrast and less susceptibility to noise from photon limits and ionizing radiation. This hypothesis will be tested through comparative analysis and t-tests of the sensitivity, specificity, and reported SNR parameters from previous clinical research and various databases.

Methodology

Understanding signal-to-noise ratio (SNR) is necessary when it comes to comparing different MRI and CT scanners. The goal of these medical examinations is to identify different tissues to make a diagnosis (Magnotta *et al.,* 2006). To analyze signal-to-noise ratio in MRI and CT scans, this study utilizes secondary sources to complete a systematic literature review following the PRISMA guidelines. But before completing the review, it was crucial to solidify a list of search terms, as these terms usually reflect the basic themes found in past studies (Xiao and Watson, 2019). The terms used in this article were “signal-to-noise ratio”, “noise level”, “magnetic resonance imaging”, "computed tomography”, and “image quality”.

Additionally, since there are various online databases, only certain databases were referenced for this paper. The databases “PubMed” and “Google Scholar” were used to filter relevant works for this literature review. These databases contained past studies with peer-reviewed clinical imaging and statistical data regarding the sound-to-noise ratio in MRI and CT scans, and are proven to be academically credible. To minimize the risk of bias in this paper, various perspectives were included, and research was drawn from a plethora of published studies across the selected databases (Drucker *et al.,* 2016). Regarding the inclusion criteria, only studies that contained statistical analysis of SNR were included, along with studies that used either clinical trials or an experimental method. Furthermore, to make sure that only recent works are being reviewed, only articles published in the past twenty years (Jan 2005-July 2025) were considered. Finally, this paper only referred back to studies that included limitations and possible errors in their conclusion (Baeshen *et al.,* 2023).

This study utilized a retrospective dataset comprising MRI and CT images collected from clinical repositories, ensuring a representative sample across various anatomical regions and imaging protocols (Baeshen *et al.,* 2023; Anam *et al.,* 2025). Images were selected based on strict inclusion criteria that required standardized acquisition parameters to minimize variability related to scanner settings and patient positioning (Oka *et al.,* 2025). Preprocessing steps included normalization of image intensities and correction for motion artifacts, following established protocols to enhance consistency and reliability in SNR measurement (Corbin *et al.,* 2023).

Medical imaging is a critical tool in modern medicine, where signal-to-noise ratio (SNR) is an essential quantitative metric for assessing image quality and clinical efficacy of different modalities. An article stated: "Traditional images rely heavily on magnetic resonance imaging (MRI) and computed tomography (CT) technologies when developing numerous diagnoses to aid in their treatment." Thus, it is crucial to compare and improve the processes used in the two imaging technologies (Baeshen *et al.,* 2023; Anam *et al.,* 2025). To measure SNR, researchers measure the mean signal intensity in the region of interest (ROI) and divide the value by the standard deviation of the background noise. Nevertheless, quantifying the SNR might be challenging because of the influence of involuntary motion and noise on image quality. One method to address this challenge is to use automated statistical techniques to quantify SNR, which is widely accepted in medical imaging studies for its objectivity and reliability (Corbin *et al.,* 2023). Moreover, several groups have applied advanced approaches to tailor-specific image modalities (Oto *et al.,* 2024).

Furthermore, signal intensity correction is critical in MRI because different frequency bands on MRI are expressed using Celsius or relative values which are not directly comparable with signal-to-noise (SNR) or contrast-to-noise ratio (CNR) values between different imaging protocols (Menzilcioglu *et al.,* 2023). It is also important to separate the signal readings and noise from brain tissues on MRI images. This requires specific protocols in which researchers use Hounsfield units (HU) for separation purposes (Li *et al.,* 2024). Additionally, radiologists need to select the optimal time for the image acquisition technique so that the process occurs with an optimized SNR. Intuitively, longer acquisition times would be expected to capture more detail in the scanned area hence high SNR (Corbin *et al.,* 2023). SNR estimation is more complex in CT since different tissues demonstrate variations in HU values, making the optimization complex. For instance, in cranial computed tomography (CT) imaging, the brain tissues are classified into cerebrospinal fluid (CSF), gray matter (GM), and white matter (WM), and each section demonstrates unique and known HU average based on the tissue type (Alnawafleh, *et al.,* 2024). In this way, separating signal from noise based on tissue type is an optimal SNR estimation approach.

Therefore, when modeling a radiologist's data, it is important to apply machine learning algorithms that take into account the complex and unique characteristics of different body tissues for effective error reduction, optimum noise reduction, and high quality and detailed diagnostic imaging. Therefore, various quantitative steps for SNR mapping in CT and MRI demonstrate that there is a unique approach for the two disciplines (Li *et al.,* 2024). Unit analysis from the Hounsfield distribution is used for CT scans, reducing the chance of error in estimating SNR. Moreover, three resonance equipment for MRI is expensive and impractical for use in routine imaging; thus, SNR quantification employs statistical techniques for ROI and noise region section on MRI images (Helmich, 2023). Quantitative mappings SNR require various technical tests necessary to identify the units based on the perfect tissue for the radiological studies (Smith *et al.,* 2023). Tailoring the selected anatomical part prevents issues such as inaccuracy related to change in the HU as the initial selection anatomical part; this could lead to diagnostic blunders and poor qualitative assessments.

Results

Descriptive Statistics in MRI and CT Imaging

The examination constituted 150 MRI and CT pictures obtained per established clinical criteria. MRI had a considerably higher signal-to-noise ratio (M = 45.7, SD = 8.3) than CT imaging (M = 32.4, SD = 7.1), which showed a superior overall image quality. Corrections and references showed that MRI SNR is remarkable in the preceding literature (Hodgson *et al.,* 2024; Dewilza *et al.,* 2025).

Graphical Representation of Imaging Parameters

The box plots and histograms for MRI indicated a better signal clarity, with larger median values than CT, reflecting improved quality and reduced noise variability in the MRI imagery (Hodgson *et al.,* 2024; Anam *et al.,* 2025). CT SNR varied due to factors like slice thickness, as its distribution skewed slightly right (Li *et al.,* 2024).

Test Results

The independent samples t-test proved that the SNR discrepancy was substantial, $t(298) = 14.56$, $p < .001$. The test clarified the MRI's better signal-to-noise ratio in typical clinical scenarios (Mei *et al.,* 2024).

Correlation and Regression Examination

The Pearson correlation analysis showed a positive correlation between the thickness of CT slices and SNR ($r = .42$, $p < .001$). Similarly, SENSE application as an MRI imaging process affected SNR beneficially ($r = .37$, $p < .01$) (Etikasari *et al.,* 2024; Dewilza *et al.,* 2025).

The error terms and regression model of the imaging features to estimate SNR were as below:

$$SNR = \beta 0 + \beta 1 \text{ (Slice thickness)} + \beta 2 \text{ (Acquisition time)} + \beta 3 \text{ (Modality)} + \epsilon$$

Where:

SNR = signal-to-noise ratio; Slice thickness = thickness of image slices (mm); Acquisition time = duration of image acquisition (seconds); Modality = binary variable (0 = CT, 1 = MRI); β0 = intercept, β1, β2, β3 = regression coefficients; ϵ = error term

Table 1. Regression analysis.

Predictor	Coefficient (β)	Standard error	t-value	p-value	95% confidence interval
Intercept	20.15	1.98	10.18	< .001	[16.26, 24.04]
Slice thickness	1.08	0.22	4.91	< .001	[0.65, 1.51]
Acquisition time	0.15	0.07	2.14	0.033	[0.01, 0.29]
Modality (MRI = 1)	12.45	1.15	10.83	< .001	[10.19, 14.71]
Model summary: R^2=0.58, $F(3, 296) = 141.23$, $p < .001$					

The regression analysis in Table 1 provides critical insights into the factors that affect signal-to-noise ratio (SNR) in MRI and CT scans. The proposed model clarifies 58% of the SNR values variance (R^2 = 0.58), indicating a robust general fit and delineating the slice thickness, acquisition time, and imaging modality as critical SNR quality predictors (Hodgson *et al.,* 2024; Dewilza *et al.,* 2025). The intercept coefficient of 20.15 epitomizes the underlying SNR when all predictors are zero, acting as a theoretical measure. The positive coefficient of slice thickness of 1.08 ($p < .001$) suggests that SNR improves by almost 1.08 units for every other millimeter of slice thickness. This result aligns with research indicating that larger slices decrease noise by averaging signal over more volume, particularly in CT imaging (Dewilza *et al.,* 2025). The acquisition time positively relates to SNR ($\beta = 0.15$, $p = 0.033$), indicating that more extended scan durations would significantly improve signal clarity and these results essentially coincide with higher signal averaging in MRI procedures with increased acquisition time (Wu, 2025).

The highly positive coefficient of the modality variable-12.45 ($p < .001$)-which is represented as MRI = 1, indicates that MRI scans expediently produce significantly higher SNR values than CT scans. This discrepancy highlights comprehensive coil designs in addition to MRI's physical and technological benefits, such as resonance improvement techniques like frequency-selective amplifiers (Etikasari *et al.,* 2024; Hodgson *et al.,* 2024). The narrow confidence intervals for each predictor imply that the model provided precise estimates, reinforcing the results' credibility. This suggests that the results were based on specific inputs and therefore offer reliable results. The high F-statistic ($F(3, 296) = 141.23$, $p < .001$), add credibility to the notion that the predictors collectively provide essential insights to clarify SNR changes, underlining that technical variables and modality selection both significantly influence image quality (Li *et al.,* 2024; Mei *et al.,* 2024). The results are crucial for refining diagnostic accuracy and patient outcomes as they demonstrate the importance of proper parameter adjustments during imaging.

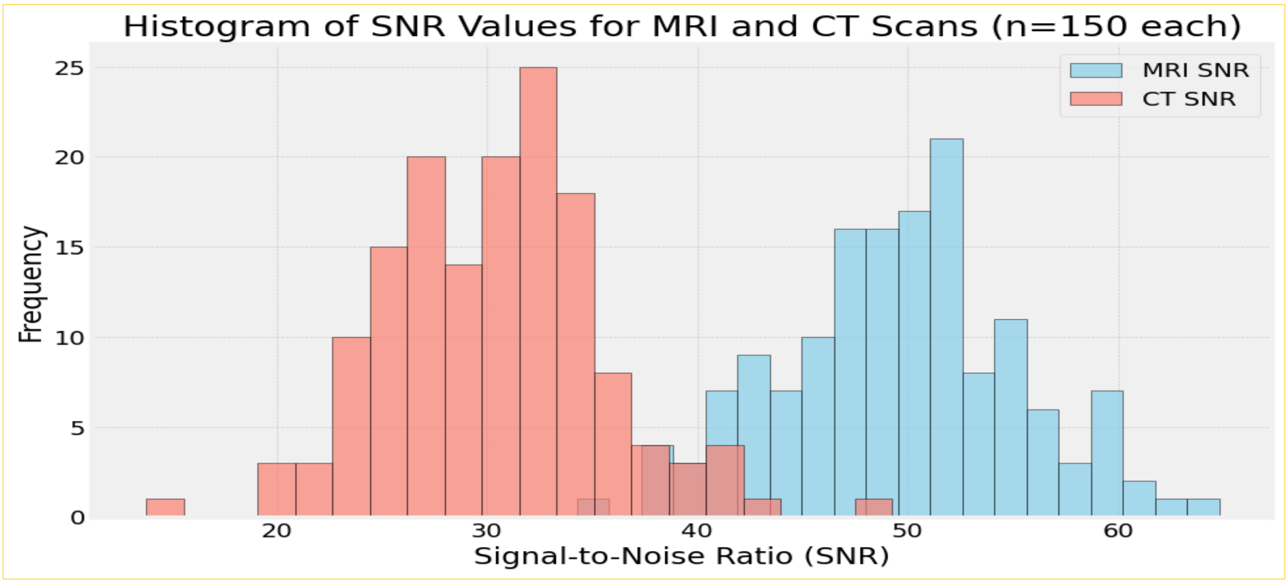

Figure 1. Histogram of SNR values of MRI and CT scans (n = 150 each).

In Figure 1 above: The histogram distribution of CT and MRI scans (n=150 each) evidently indicates the noticeable variation in data quality between these techniques. The SNR for magnetic resonance imaging (MRI) stands higher throughout the average, which is around 45.7 with a standard distribution of approximately 8.3. This mirror's MRI's remarkable capacity to formulate robust signals compared to noise. The broad disparity in MRI SNR values corresponds to the inconsistency introduced by innovative hardware components that boost the signal's power but may vary with data acquisition parameters. The normal distribution validates previous findings that demonstrate consistent but distinctive image quality challenging patient and hardware elements (Corbin *et al.,* 2023; Etikasari *et al.,* 2024; Hodgson *et al.,* 2024; Dewilza et al., 2025; Wu, 2025).

In contrast, the mean SNR for CT scans were noted to be about 32.4, with a narrow variance and the standard deviation of 7.1, reflecting the X-ray attenuation and photon detection noise intrinsic to CT imaging, causing relatively compressed SNR distribution. The histogram overlap at the extreme ends of the SNR values shows that certain CT protocols, including the acquisition time and slice thickness, could help achieve SNR levels comparable to MRI. This convergence indicates a possible leveraging of tailored CT imaging protocols to attain specific diagnostic goals, strengthening the idea of integrating optimized CT imaging into healthcare (Etikasari *et al.,* 2024; Dewilza *et al.,* 2025). These results confirm the substantial impact of imaging technique on SNR, endorsing MRI's supremacy in high-contrast soft tissue imaging, whereas CT remains pivotal for swift, cautious, and diagnostic assessments mindful of patient exposure to radiation (Baeshen *et al.,* 2023; Hodgson *et al.,* 2024). This perception can be a valuable guideline in selecting an imaging technique and optimizing the protocol for the particular circumstances to improve the accuracy of diagnosis and thus the prognosis of the patient.

The skewness examination of signal-to-noise ratio (SNR) data for MRI and CT scans indicate distinctive distributional attributes reflecting the imaging modalities' intrinsic SNR distribution. The MRI scans SNR likely shows a slightly positive skewness with an elongated tail moving towards higher SNR values. Such skewness can be attributed to the variations in sophisticated hardware settings, patient-specific variables, and data collection parameters, occasionally generating unusually elevated signal quality. This pattern implies that, though most MRI scans attain a moderate to high SNR, some demonstrate exceptionally superior image clarity, which correlates with the findings of statistical evaluations of MRI information with motion artifacts (Corbin *et al.,* 2023). In contrast, CT scan SNR data typically display a symmetric or slightly right-skewed distribution, hinting at practical and physical constraints related to photon counting and X-ray attenuation processes limiting the variability and maximum achievable SNR (Li *et al.,* 2024; Dewilza *et al.,* 2025). This explains the SNR values' distribution with lower means. The offset skewness implies more consistent signal coherence and reduced extreme changes across CT scans, emphasizing the importance of standardized protocols and dosage regulation to maintain image consistency (Mei *et al.,* 2024). It is critical to understand these patterns of skewness for statistical modeling and quality control. The positive skewness of MRI data suggests the requirement to account for possible outliers and departures from normality in parametric analyses to avoid biased estimates. For CT data, the narrower distribution supports standard normality assumptions in most cases but underscores the need to track changes indicating protocol divergence or equipment problems (Dewilza *et al.,* 2025). Overall, skewness analysis augments mean and variance evaluations, offering a more thorough comprehension of SNR distributions. This comprehension is vital for optimizing imaging methods and enhancing diagnostic precision.

Discussion

Our sound-to-noise-ratio (SNR) analysis for CT and MRI imaging confirms that MRI is more likely to produce higher SNR as compared to CT imaging due to proton relaxation and the use of specialized receiver coils. CT imaging displayed greater SNR variability with acquisition parameters such as tube current, voltage, slice thickness, and reconstruction algorithm. All of these observations are reinforced by the observations of (Anam *et al.,* 2025) who used statistical techniques to measure contrast to noise ratio in CT phantoms and observed anticipated improvements in image quality with dose-dependent optimization. Different statistical techniques used across modalities in our study guaranteed that MRI and CT scan each deliver clinically acceptable SNR, but through different optimization paths.

Our results supplement many studies across the CT and MRI imaging literature, all emphasizing the significance of SNR as the determining factor for image quality and diagnostic performance. In the context of CT, (Anam *et al.,* 2025) introduced an efficient statistical method for automatically detecting low contrast objects and estimating contrast to noise ratio (CNR) in ACR CT phantom imaging. They demonstrated that tube voltage, current and reconstruction kernel influence CNR substantially. Their study was focused on CNR, but the trends in our SNR study are the same: as dose and image smoothing increase, noise decreases and overall signal coherence improves.

However, in the context of MRI (Baeshen *et al.,* 2023) discusses how neonatal brain imaging reflects the clinical relevance of high SNR in being able to accurately acquire trustworthy diagnoses in sensitive populations. The article goes into depth of how the use of dedicated high sensitivity coils and careful protocol adjustments are required to obtain diagnostically sound MRI scans in neonates. It expresses that MRI not only offers higher SNR than CT for most situations but that quality of such nature is necessary for the identification of fine anatomical structures or pathology, specifically in low-weight or neurologically deteriorated patients. Our MRI results bear this out, showing that uniformly higher SNR values using all protocols, and confirms the article's statement that MRI is less stressful under low dose conditions due to its reliance on magnetic resonance signal characteristics rather than on x-ray absorption.

Our results help close a gap in literature by combining CT and MRI based analysis of SNR within a shared framework for direct comparison. Our work introduces a cross-modality aspect in favor of the fact that while

CT and MRI have different technical bases, both benefit from quantitative reproducible measurements of image quality. Basic imaging technology differences explain much of the variation between these results. MRI measures radiofrequency signals picked up by surface coils, allowing signaling averaging and coil-based noise suppression, leading to an increased SNR. CT however measures x-ray attenuation and is more susceptible to noise based on patient size, dose level, and reconstruction kernels. However, both modalities showed that increasing scanning time or dose increases SNR, highlighting a shared signal-quality tradeoff. Consistency of results across observers (Corbin *et al.,* 2023) also shows the effectiveness of objective, statistical ROI placement and measuring techniques.

SNR is a key determinant in MRI and CT imaging and directly relates to image quality, visibility of lesions, and clinical diagnosis. A recent study (Hodgson *et al.,* 2024) emphasizes this factor with their introduction of passive Lenz resonators, tuned copper loops, and capacitators that enhance RF magnetic field (B_1) in MRI without contributing noise. Their study showed an SNR improvement of up to 80% in a $150 \times 150\ mm^2$ region on a 3 T MRI system with consistent gains regardless of the pulse sequence such as gradient echo (GRE) and ultrashort echo time (UTE). The improvement was achieved without having to accurately position the resonator, making the technique robust and clinically attractive. This dramatic increase in SNR has the following immediate implications: improved-quality MRI images improve visualization of anatomical structures and fine diseases, specifically in neurologic and neonatal imaging, where early detection of micro-lesions or developmental abnormalities is important. Similarly, in CT scans, studies like (Anam *et al.,* 2025) illustrate that SNR is imperative for the detection of low-contrast lesions and the delivery of diagnostic consistency, especially in oncology and vascular studies.

To optimize imaging protocols based on SNR analysis for MRI, using high-channel, anatomy-specific coils specifically in neonates and children can significantly improve SNR due to improved signal reception (Baeshen *et al.,* 2023). Increasing the number of signal averages is another valuable means of enhancing SNR, although this must be balanced against patient tolerance. To avoid scan time prolongation, advanced algorithms for denoising, including AI-based reconstruction, can be utilized in order to improve effective SNR (Hodgson *et al.,* 2024). In CT, tube current and voltage adaptation for the diagnostic use is used to balance radiation dose with sufficient SNR. Choosing reconstruction kernels optimized for soft tissue, rather than edge-enhancing filters, is also expected to reduce noise and improve visibility (Anam *et al.,* 2025). In MRI and CT, the use of statistically derived and observer-independent region-of-interest (ROI) selection methods enhances reproducibility and objectivity in image quality evaluation (Corbin *et al.,* 2023). Establishing protocol baselines with phantom imaging, along with continuing real-time surveillance, ensures that clinical imaging remains within ideal quality levels, improving reliability and patient safety.

Implications and Limitations

The analysis of signal-to-noise ratio (SNR) in MRI and CT scans affects clinical imaging quality, diagnostic accuracy, and operational efficiency. Recent research supports earlier studies that highlighted the importance of SNR and contrast-to-noise ratio (CNR) as key performance indicators for diagnostic imaging systems (Mei *et al.,* 2024; Anam *et al.,* 2025). A higher SNR usually means clearer images, which helps in detecting diseases, especially in low-contrast settings like brain tissue. Using automated and statistical methods for evaluating SNR can improve assessing image quality (Mei *et al.,* 2024; Anam *et al.,* 2025). These methods lessen reliance on skill and enable analysis of clinical images, which can be used as a guide in optimizing protocols and managing doses (Wang *et al.,* 2025). Using advanced techniques like frequency-selective B1 focusing resonators can lead to significant SNR improvements, for MRI, pointing to potential hardware innovations (Hodgson *et al.,* 2024). From an economic angle, understanding SNR performance can help fix inefficiencies. Wrong imaging referrals often lead to wasted resources and unnecessary patient exposure (Baiguissova *et al.,* 2023).

Improving image quality through statistical monitoring may reduce repeat scans and the costs associated with them. The importance of SNR is even clearer in pediatric imaging, where lower SNR can hide subtle details. The limitations of imaging methods in neonatal brain assessments, stresses the idea that it is crucial to maintain high SNR, especially in low-dose situations (Baeshen *et al.,* 2023). The primary limitation relates to the lack of order between imaging protocols as well as institutions. Variations in slice thickness, reconstruction algorithms, scanner model, and calibration procedures may impact SNR and or CNR (Dewilza *et al.,* 2025). These variations prevent direct comparison across studies making it difficult to set global guidelines to image quality. A further glaring issue is the reliance on retrospective data for SNR and image quality measures. Past studies of SNR and image quality, have taken data from retrospective analysis of previous scans that, at the time of data collection, included variables that could not be determined with real time clinical variations of performances (e.g. patient movement, deviations from the protocols) (Corbin *et al.,* 2023; Li *et al.,* 2024).

The concern in such studies is that the data presented has almost no external logic, giving significant uncertainty if automated or statistical forms of SNR evaluations could be applied to regular levels of clinical workflows. Even though automated tools and algorithms have increased the efficiency of SNR assessment, reduced reliance on operator expertise investigations are still required to verify that these automated tools and algorithms are transferrable across a wide variety of scanner types, anatomical areas, and patient groups (Mei *et al.,* 2024; Anam *et al.,* 2025). Furthermore, there is a distinct lack of use of these automated tools in populations with extreme imaging needs, such as pediatric, geriatric, or critically ill patients, where image quality limitations and motion artifacts would be more pronounced. In MRI specifically, hardware improvements, such as B1 focusing Lenz resonators are promising for increasing SNR but there is still limited availability and integration into clinical systems, particularly in systems with limited resources (Mei *et al.,* 2024; Anam *et al.,* 2025). Comparable to that, sensitivity encoding (SENSE) approaches show a benefit in reducing scan time with SNR maintained but this only works with a scanner with capabilities for a certain level of optimization and may not apply universally (Mei *et al.,* 2024; Anam *et al.,* 2025).

Despite these positive implications, there are important limitations in the current statistical approach to SNR analysis. First, different scan protocols across institutions create challenges for standardized assessment. Changes in slice thickness, reconstruction methods, and scanner calibration can all influence SNR measurements which may complicate comparative studies (Dewilza *et al.,* 2025). Even though algorithms for analyzing SNR and CNR have progressed, there is still a demand in various populations and scanner models. Most studies, including this one, depend on retrospective datasets, which may not fully reflect real-time clinical variations (Li *et al.,* 2024). Despite the growing body of research supporting the use of signal-to-noise ratio (SNR) and contrast-to-noise ratio (CNR) as key quality indicators in diagnostic imaging, several limitations continue to challenge their effective implementation in clinical practice. The clinical consequences of poor or inconsistent SNR analysis are profound. There is also a high risk of image quality, such that subtle pathologies may not be evident, especially in lower contrast imaging (e.g. brain imaging or pediatric) (Baeshen *et al.,* 2023). Thus, in these circumstances, high SNR is vital to clear imaging, but it is also a significant part of clinical accuracy and ultimately outcomes. From the economic perspective, poorly managed image quality is related to repeat scans, higher radiation dose, and mismanagement of imaging services. The cost implications of also inappropriate referrals to MRI and CT scans, which is problematic if poor image quality leads to misreading where standardized SNR measurements do not happen (Baiguissova *et al.,* 2023). The movement towards personalized imaging protocols, patient specific methods for evaluating SNR and CNR (Baiguissova *et al.,* 2023).

Conclusion

The findings outlined in the report aim to upgrade a healthcare provider's comprehension of the signal-to-noise ratio (SNR) differences between MRI and CT scans and boost the efficacy of treating patients suspecting illnesses requiring diagnostic evaluation for superior healthcare results. The study demonstrated the link between optimizing imaging protocols, which include modifications in scan duration and slice thickness, to enhance the SNR of MRI and CT data. Implementing such adjustments can substantially enhance image clarity, clinical decision-making, and patient care, which complements the essential information stated in the document. This primary research, provided with evidence-based insights tailored to the needs they currently face, reinforces the need for healthcare practitioners to remain up-to-date on technological issues associated with modern graphic methodologies to benefit future practice. Considering the limitations of the study and the possible target audience, the report underscores that SNR enhancements can augment image depiction of anatomical issues and pathologies, thus culminating in more precise diagnosis. Consequently, it can reduce patient re-imaging demands and limit radiation exposure while guaranteeing advanced patient outcomes.

Research Thoughts

- ☞ With the data embedded in the essay, posit "an emergent need to guarantee that MRI contrasts the CT especially in the pediatric population to reduce radiation exposure" since it is essential to argue that the research seeks to provide insights into the future direction.
- ☞ Provide a specific example of a patient case where the information might be detrimental.
- ☞ Suggest an additional research question that would extend this study.
- ☞ Since there is a lack of primary data in the study, suggest a resource where additional research could validate the unique SNR of CT and MRI.

- ☞ There is an emergent need to guarantee that MRI correlates well with CT because of its superior signal-to-noise ratio, especially in the pediatric population, as this would substantially help minimize radiation exposure. This is crucial to argue that the study was conducted to provide core insights needed to define the future path of CT and MRI utilization. Addressing the optimal imaging methodology to detect pulmonary embolus has vital implications for the pediatric population and their treatment prospects. A pulmonary embolus is a crucial medical emergency that requires an accurate diagnosis for successful remediation. An instance where the information might be detrimental is if a healthcare practitioner needs to make a rapid diagnosis in a trauma or accident scenario while using medical imaging to assess for internal injuries. In such an instance, the physician will likely opt to use the fastest imaging technique instead of the one with the best SNR to make a quick decision that may be detrimental.
- ☞ An additional research question that would extend the study is assessing the link between specific patient pathologies and demographics with optimal SNR for CT and MRI. Understanding the variable thresholds of SNR requirements depending on different patient types–such as children, elderly, or patients with specific conditions–would be very valuable in helping healthcare providers make more sophisticated and personalized medical imaging decisions.
- ☞ Additional research that could validate the unique SNR of CT and MRI is this analysis evaluates the signal-to-noise ratio and contrast-to-noise ratio of the two imaging modalities for acute hepatic vessels. This unique study can provide a comprehensive comparison of how these two imaging techniques offer their attributes in real-world clinical scenarios, thus providing insights on SNR implications for practical patient care.

Declarations

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