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MRI Artifact Analysis and Correction Techniques

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Abstract: ***Background**: This research plays a strong role on explaining the different number of artifacts occurrence due to software, hardware, human physiological functions with the aim of promoting artifact detection and corrective remedies needed to optimize and increases the image quality in Magnetic Resonance Imaging. Especially it is to understand origin of artifacts and mimic the pathology as they can lead to misdiagnosis. **Objective**: The primary objective of this article is to unlock the goals with these proven objective-setting strategies that MRI artifacts and highlights clues which suggest the rectification. **Methodology**: This was a prospective study which included all the patients that were referred to our centre for various MRI examinations. The study was carried at 1.5 Tesla Symphony MRI, March Imaging & Diagnostic Center, Bikaner India. All MRI examinations were conducted under the supervision of an experienced radiologist and performed by trained technologists. During the imaging process, the acquired MR images were carefully assessed for the presence of artifacts. The focus was on identifying the specific MR parameters at which these artifacts occurred. Following the identification of artifacts, appropriate remedial measures were promptly implemented to address and mitigate their impact on the image quality. **Result**: A total of 169 patients comprising 88 females and 81 males, referred to our department for MRI examinations of various body parts were studied. The commonest artefact observed was motion artefact in 120 (55.56%) patients followed by susceptibility artefact, Gibb's artefact, and aliasing artefact. Less common artefacts observed were chemical shift artefact, shading artifact, high impulse noise, and zipper artefact. **Conclusion**: MRI can be significant challenge in diagnostic imaging. However, with knowledge and appropriate measures, they can minimize and overcome. As a radiographer we must continue to learn and adapt the parameters and conditions of medical imaging to provide best possible outcome.***

Keywords: MRI artifacts, Remedies, Image Interpretation, Image Distortion, Chemical shift, Artifact correction, possible rectifying methods

1. Introduction

1.1 History of MRI

Damadian created a rudimentary Nuclear Resonance and Imaging (NMR) image of a rat tumor in 1974. It took nearly four hours to create the first body imaging image, which was completed in 1976. At the same time, Paul Lauterbur, an NMR chemist at the State University of New York, created a technique known as "Zeugmalagraphy". Similarly, the early development of MRI was greatly aided by a number of scientists and chemists. Lauterbur and Mansfield shared the 2003 Nobel Prize in Physiology and Medicine.[1] The ability to provide contrast and spatial resolution, thorough coverage of anatomy suited for certain uses, and the capacity to produce both two-dimensional (2D) and three-dimensional (3D) images distinguish this imaging approach from others. It also provides the benefit of multiplanar imaging and the absence of ionizing radiation.[2]

1.2 What is Artifact?

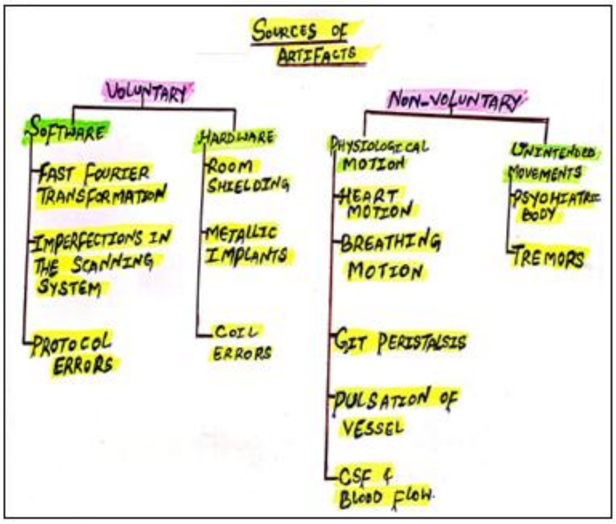
MRI has the potential to create artifacts due to a failure, breach, or violation of one or more imaging principles, just as other diagnostic imaging technologies. Sequences or images might have a variety of artifacts. There is no accepted definition for the term "artifact" in MRI. MR artifacts have the potential to seriously deteriorate images and cause misunderstandings.[3] While some artifacts do not affect the quality of the MRI exam, others may be misconstrued for pathology. An artifact can also be defined as a synthetic element that is present in an image but not present in the original object of investigation.[4] The latter could potentially affect image diagnosis (misinterpretation), especially when studying pathologic situations.

Due to this multiparametric reliance, the soft-tissue contrast is considerable and varies. While not all artifacts may be eliminated entirely, they can all be reduced to a bearable degree.[6]

1.2 What are the Source of artifacts?

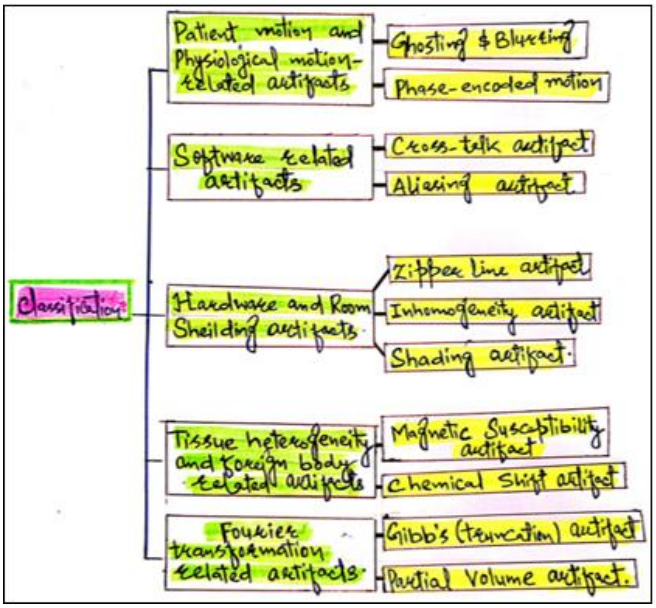
Artifacts can be traced back to their separate origins and are typically categorized into three categories: equipment-related, image reconstruction-related, and patient physiology-related. This is mostly due to the lengthy imaging process. The rate at which different physiological motions take place is a significant factor in how they manifest. Blood vascular pulsation, heart and breathing motion, GIT peristalsis, involuntary motions, and blood and cerebrospinal fluid (CSF) flow are all significantly impacted by their corresponding rates of occurrence. [4,6-11]. For spatial encoding, magnetic resonance imaging mainly relies on the Fourier idea. Gradient fields are employed to encode the MR signal into a spatial form, and the image is then reconstructed using a Fast Fourier transform. Artifacts such as Gibbs' ringing artifact and the Partial volume artifact are examples of the complex interaction that exists between artifact patterns and their sources.[6] The sensitivity of some materials can cause signal dropouts, motion blur, and dislocation. Numerous factors, such as the subject's inherent characteristics, differences in movement and other data, and flaws in the imaging apparatus and system, can result in common picture artifacts. These artifacts can result in photos that are difficult to comprehend because of issues including distortion, noise, and blurring. Recognizing the significant sources of visual artifacts and taking proactive steps to lessen their effects are essential to addressing these problems.[3]

A more thorough view of a patient's general health is given to medical practitioners by all of these different data points.



Flowchart 1: Classification of sources of artifacts in MRI

Gibbs and motion artifacts are two of the main sources of data used in this investigation. A number of things, including as poor calibration, system noise, and electromagnetic interference, can cause Gibbs artifacts. In contrast, biological motion such as breathing, heartbeat, peristalsis, blood, and CSF flow pulsation are examples of motion artifacts. Any non-voluntary movement that a patient may be displaying, like tremors or twitches, is referred to as physiological motion. Eye twitches and blinks are examples of involuntary movements that a patient is unable to consciously control. Where to find artifacts Fast Fourier transformation in software that is voluntary the scanning system's flaws and protocol problems Shielding of the Hardware Room Metal implants Errors in coils Involuntary The motion of the body GIT peristalsis, heart motion, breathing motion, vessel CSF pulsation, and blood flow. Unintentional motions Psychiatric motions of the body Four Tremors The movement of the heart, or cardiac motion, is used to calculate a patient's heart rate. The movement of the lungs and airways is referred to as respiratory motion, and it aids in determining the patient's breathing rate. The movement of the digestive tract, known as gastrointestinal peristalsis, can be quantified to assess a patient's digestive health. Blood pressure is measured by vessel pulsation, which is the movement of the veins and arteries.



Flowchart 2: Classification of artifacts observed based on MRI 1.5T Symphony.

1.3 Artifact Recognition

Basically, considering the possibility an artifact in MRI begins in 2 ways:

First off, inconsistent picture detection when employing pattern recognition is highly suggestive of artifact. Pulsation artifact and Gibbs artifact are examples of this type. Figure 1.1 demonstrates pattern recognition types.

An artifact may also be a finding that deviates from typical anatomical boundaries or aberrant impulses that go through the bone, brain, or CSF but do not attach to these tissues. In these sections, metallic and ghost artifacts are clear examples. Imaging tests will be conducted in the future to validate that suspicion. [12] Figure 2 display this metal artifact and signal loss. There are numerous additional methods for classifying the artifacts according to the signal contribution to the MR picture and distinguishing between static and dynamic artifacts, including signal loss and aliasing artifact.[6]

1.4 Is artifacts are important?

Distortions or anomalies in the final image that are not indicative of the patient's actual anatomy are known as MRI artifacts. However, it is important to remember that radiologists and other medical practitioners can also learn a lot from MRI abnormalities. In actuality, they can offer important research and diagnostic data in addition to chances for advancement in the medical imaging industry. Researchers, doctors, and technicians can all benefit from understanding MR artifacts. Recognizing MR artifacts can help technicians use the appropriate strategies to lessen or avoid them. To differentiate MR artifacts from true diseases, doctors need to be aware of them. Finally, artifacts can serve as the foundation for novel MR methods. [6] Consequently, it is critical to acknowledge the significance of MRI artifacts and endeavor to comprehend and make efficient use of them.

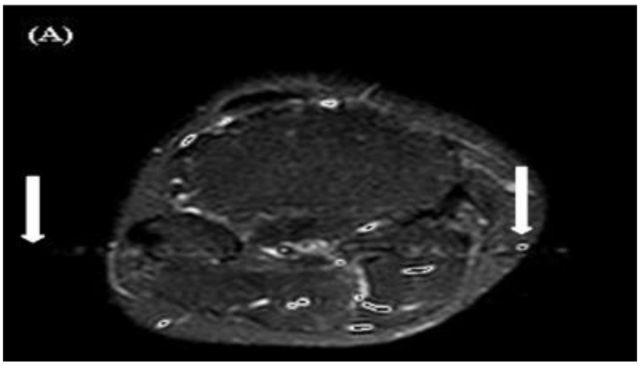


Figure 1.4.1 A. Pulsation artifact shows bright linear structure of popliteal vessel along phase encoding direction in few image frames

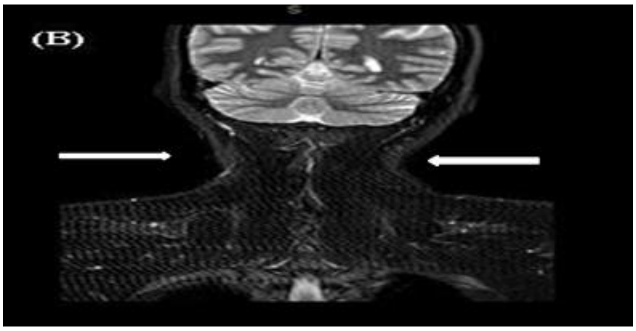


Figure 1.4.1 B. Zipperline artifact showing bright and dark bands alternatively in image.

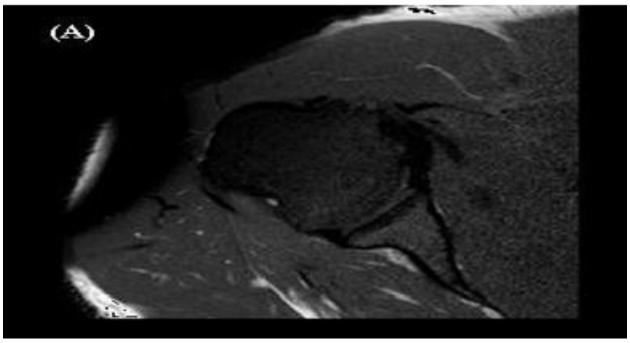


Figure 1.4.2 (A): Showing signal loss due to imperfect coil position on anatomy.

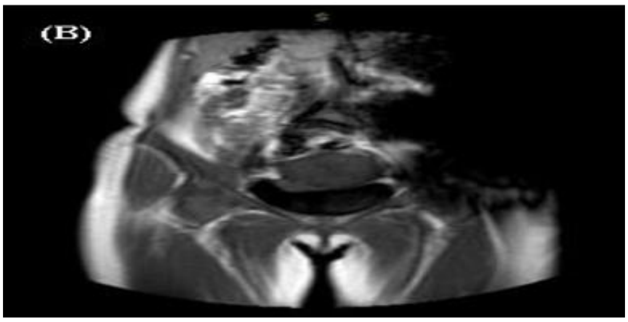


Figure 1.4.2 (B): Magnetic supectability artifact appeared due to hook inside salwar later it was corrected by removing the respective cloth.

2. Aim & Objectives

2.1 Aim

The aim of this research is to investigate and develop effective techniques for analyzing and correcting Magnetic Resonance Imaging (MRI) artifacts, with the ultimate goal of improving the accuracy and reliability of MRI images for diagnostic and therapeutic purposes.

2.2 Objectives

1) The study aims to identify and calculate the causes, reasons, and correction methods of various MRI artifacts.
2) MR technologists may be better equipped to choose suitable techniques by having a deeper understanding of MR artifacts.
3) How can we compensate artifacts in MRI?

2.3 Hypothesis

The implementation of corrective measures for MRI artifacts will significantly improve the diagnostic accuracy and overall quality of MRI imaging.

Justification: The quality and accuracy of imaging can be greatly impacted by MRI artifacts, which may result in inaccurate diagnosis and treatment recommendations. There are, however, a number of remedial techniques that can lessen the effect of artifacts on MRI imaging. We may be able to raise the general quality and diagnostic precision of MRI imaging by putting these remedial actions into practice.

3. Review of Literature

3.1. This article investigates MRI artifacts and their causes in a prospective study at Tesla Magnetom avanto Siemens in Germany. The study involved 209 patients, with motion being the most common artifact (20.6%). Other artifacts included susceptibility and aliasing. The article provides a detailed explanation of observed artifacts and corrective images, emphasizing the importance of understanding the origin and process of these artifacts for effective correction and counteraction.[7]

3.2. This article explores the use of MR imaging, including blood flow, cardiac activity, biochemical cycles, growth energy, and BOLD. It highlights the importance of understanding artifacts and suggests implementing a quality control program to limit system-related artifacts. The author also discusses Fast Fourier transform, artifacts, safety issues, and quality control within the MR imaging system, aiming to improve patient care and technology effectiveness. [11]

3.3. The article discusses the impact of radiological artifacts on clinical diagnosis, highlighting their prevalence and removal techniques. A retrospective study by four radiologists and one resident examined 514 patients, identifying 252 artifacts in 22 patients. Common artifacts include movement artifacts (38%), Gibb's artifacts (145), metallic artifacts (106), and cross talk artifacts (31%). The study highlights the importance of identifying artifacts for accurate picture analysis, selecting suitable rectification methods, and using modern scanning techniques to achieve high diagnostic quality.[8]

3.4. The review discusses motion artifacts, a common issue in image acquisition, especially in MRI. They can manifest in motion blur, buffering, signal interruptions, and unintended signal amplification. The article reveals that a universal correction tool is not available for all artifact types. Instead, a toolbox of techniques with specific parameters is available. Advancements in technology, such as faster imaging and parallel imaging, have improved motion artifact mitigation.[13]

3.5. This paper outlines the categories of artifacts and visual characteristics of foreign objects that can appear during MRI scans, aiming to prevent mistaking them for pathological conditions. Artifacts are divided into groups, including newborns, cosmetics, dental materials, and metallic objects. Radiologists often lack information about a patient's medical history, leading to unfamiliar images. Understanding these artifacts and their origins is crucial for mitigating their impact on MRI images and modifying acquisition parameters. [14]

3.6. This article provides an overview of common artifacts in MRI imaging and their corrective strategies. It highlights various types of artifacts, such as Truncation, aliasing, Magnetic susceptibility, central point, zipper, motion, chemical 11 shift, crosstalk, and partial volume artifacts. The article emphasizes the importance of a radiologist in identifying and addressing these issues, ensuring accurate interpretation and diagnosis. It also presents strategies for avoiding or reducing these artifacts. The key recommendation is to have a basic understanding of artifacts and the specific MRI facility being used in practice.[5]

3.7. The research paper investigates techniques to reduce susceptibility artifacts and enhance image quality in Cardiac Magnetic Resonance (CMR) images. CMR is a valuable tool for detecting and characterizing heart conditions without invasive procedures. However, certain artifacts, such as susceptibility and chemical shift artifacts, and motion artifacts from respiratory and cardiac motion, can affect the quality of the images. A prospective study involving 16 adult patients with long-lasting pacemakers revealed that the range of artifacts caused by the generator was more extensive in bSSFP sequences compared to SPGR, primarily due to the presence of stripes. The study concluded that artifacts triggered by pacemakers usually do not ruin the diagnostic intelligence quotient. Adopting a frequency scout before bSSFP cine or using SPGR-based sequences may improve results.[15]

3.8. This article explains the various artifacts in magnetic resonance imaging (MR) techniques, which can be categorized into four types: hardware, sequence, patient, and specific to certain techniques. These artifacts affect the pathology of the MR signal, degrading image quality and leading to misinterpretation. Multiple techniques exist to minimize or prevent the occurrence of these artifacts. Understanding MR artifacts allows operating personnel to select appropriate techniques to compensate or prevent them, while physicians must be familiar with potential artifacts to differentiate between them and actual pathologies affecting the MR signal. Artifacts also serve as a foundation for new MR techniques. [6]

3.9. This article explains the various artifacts in magnetic resonance imaging (MR) techniques, which can be categorized into four types: hardware, sequence, patient, and specific to certain techniques. These artifacts affect the pathology of the MR signal, degrading image quality and leading to misinterpretation. Multiple techniques exist to minimize or prevent the occurrence of these artifacts. Understanding MR artifacts allows operating personnel to select appropriate techniques to compensate or prevent them, while physicians must be familiar with potential artifacts to differentiate between them and actual pathologies affecting the MR signal. Artifacts also serve as a foundation for new MR techniques. [16]

3.10. The expert aims to address Gibbs ringing artifacts in imaging data by examining and developing methods to eliminate or reduce their presence. Traditional data acquisition methods, such as Cartesian grids, result in Gibbs artifacts. Techniques like the Lanczos-based local averaging method and hybrid Gegenbauer reconstruction are used for noise reduction and ringing removal. Other methods include re-interpolation, convolutional neural networks (CNNs), and PF reconstruction. However, these methods also cause Gibbs ringing artifacts. A recent study by Muckley used a CNN to simultaneously remove Gibbs ringing artifacts and reduce noise in PF-acquired data. This approach effectively eliminated ringing in PF acquired complex images but only partially removed ringing in PF acquired magnitude images, particularly for heavily under-sampled data. The techniques also reduce image sharpness by blurring, aiming to improve the quality of PF-acquired images. [17]

3.11. The study aims to correct metal artifacts in new generation low magnetic field MRI (MRI) systems to improve image quality. The authors propose using slice encoding for metal artifact correction (SEMAC) to reduce magnetic artifacts and improve image appearance. They used hip implants made of titanium and cobalt chromium, which mimic gel medium. Protocols included View angle tilting (VAT) and Turbo spin echo (TSE) techniques, with encoding ranging from six to fifteen and receiver bandwidths from 200 to 425 Hz/px. Turbo factors ranged from 8 to 23. Statistical analysis showed that SEMAC MRI significantly reduced metal artifacts at 0.05 Tesla, while magnetic susceptibility artifacts were lesser at 0.55 Tesla. The authors suggest that 15 artifacts around hip implants are better reduced in SEMAC MRI than 1.5 Tesla MRI. [18]

3.12. This study aimed to evaluate the effectiveness of reduced field of view (FOV) acquisition techniques and retroactive distortion correction techniques in breast imaging. The study involved 169 women undergoing clinical breast MRI on three Tesla with reduced FOV in DW EPR sequence. The researchers used data analysis tests to assess the impact of disparities observed in the evaluations. They found small residual distortions in both reduced and full FOV EPI images. Axillary nodes were visible in most cases, but lingering misrepresentation was more common in full-FOV images. The study concluded that the Removal of Partial Fourier-induced Gibbs (RPG) method helped reduce distortion in reduced-FOV EPI data without omitting important information. However, improvements were not as significant in full-FOV images, and correction near the nipple was limited.[19]

3.13. The study aims to reduce metal artifacts in brachytherapy planning for cervical cancer using magnetic resonance imaging (MRI). The presence of metallic tandem, elliptical vaginal injector, and 16 labels can cause magnetic susceptibility artifacts in MRI scans, potentially leading to misdiagnosis and distortion of surrounding tissue. To reduce these artifacts, a technique called metal artifact reduction sequences (MARS) was used, focusing on orthopaedic metal artifact reduction (O-MAR). O-MAR combines MARS characteristics with VAT and SEMAC to decrease susceptibility artifacts in both in and through plane orientations. A group of seven cervical cancer patients observed a significant decrease in metallic disturbance at the tandem tip during proton density weighted MRI scans, improving image quality and visibility of affected areas. [20]

3.14. The article explores the issue of head motion in resting-state functional MRI (rs-fMRI) studies and the various methods used to address it. The authors highlight the negative effects of head motion on data, such as decreased signal-to-noise ratio, motion-related artifacts, and compromised data quality. They emphasize the need for efficient motion correction techniques to ensure reliable analysis and interpretation of resting-state brain connectivity. The article reviews various head motion correction methods, including volume-based and image-based methods, and presents their advantages and limitations. The authors also discuss recent developments in motion correction, such as slice-to-volume registration, multi-echo acquisition, and motion scrubbing techniques. The article provides valuable insights into the effects of motion and guides the selection of appropriate correction methods to improve the accuracy and reliability of resting-state brain connectivity analyses.[21]

3.15. The research paper aims to identify and reduce unexpected artifacts in MRI studies that cause confusion and loss of time during examination. These artifacts include hair oil artifacts, Kajal-related artifacts, earwax-related artifacts, and fused light bulb-related artifacts. Hair oil artifacts are more prominent on gradient echo images and are caused by hair oils, which are a combination of mineral and vegetable oils. Kajal-related artifacts are caused by various substances in its composition, including lead, aluminum, antimony, carbon, iron, zinc, camphor, and menthol. Earwax-related artifacts are caused by earwax turning stone, while fused light bulb-related artifacts are caused by tungsten filament fused light bulbs.[22]

3.16. The study investigated the impact of the chemical shift artifact, caused by misalignment or phase cancellation at the compact and trabecular bone interface in MRI. The artifact, which arises from the different precessional frequency range of water and fat protons, makes it difficult to accurately determine the meeting point between trabecular bone and water-dense compact bone. Using a one-point five Tesla MR unit with a bird cage coil, statistical analysis revealed that mathematical correction could eliminate the discrepancy between MR images and radiographs. The authors emphasize the importance of acknowledging and reducing the artifact in MR imaging studies of the equine distal limb. [23]

3.17. A study aimed to assess the presence of magnetic resonance imaging (MRI) artifacts from cosmetics, including eye touch-up, nail glitter, skin care products, and hair loss highlighters. 38 cosmetics were tested, with 37% showing artifacts. The artifacts, often linked to iron oxide or other metal-based ingredients, were evaluated using a qualitative 19 scale. The findings suggest that commonly used cosmetics can cause confusion if the affected area coincides with the region of interest or if the cosmetic's presence is unknown, potentially leading to misinterpretation as abnormality. These findings have significant implications for patients undergoing MRI tests.[24]

3.18. The academic paper focuses on identifying and correcting artifacts in musculoskeletal MR imaging due to the complex relationship between the main magnet, gradient coil, RF trans receiver, and reconstructive algorithms. These artifacts can reduce image quality and mimic pathological conditions. The paper discusses motion artifacts, protocol error artifacts, susceptibility artifacts, and chemical shift artifacts. The images were obtained from a 3T MRI machine and their occurrence, underlying physics, and potential corrections are demonstrated.[25]

3.19. The article discusses a hairy situation with magnetic susceptibility artifacts on MRI, focusing on two research cases. The first case involved a patient with trendy hair matting, which was caused by the use of pigmented beeswax. The paramagnetic effect was attributed to the use of black beeswax, a common ingredient in cosmetics with iron and cobalt pigments. The second case involved a patient with a clay paste with iron oxide on her braids, a common hairstyle in the 20 African American community. The article highlights the importance of understanding hairy situations for MR technologists. [26]

3.20. A study examining the safety and experience of individuals with active deep brain stimulation (DBS) systems found that existing MRI safety guidelines limit access to MRI for patients. The study analyzed hardware-related artifacts in functional MRI images and evaluated 102 participants, mostly men, aged 60 and above. No adverse events or immediate changes related to MRI were observed. However, noticeable artifacts were observed near electrode connections and the frontal parietal cortex in patients with DBS, which largely obscured the apparent frontal parietal cortex and adjacent deep cranial areas. The study concluded that patients undergoing DBS can safely undergo 1.5 and 3.0 T MRIs after appropriate local safety testing, and that artifacts related to DBS hardware only affect a lesser portion of brain tissue. [27]

3.21. This article discusses metal-induced MR artifacts and discusses strategies to reduce them by adjusting MRI parameters and considering patient factors. It also lists advanced imaging techniques suitable for patients with metal implants, enhancing diagnostic confidence and image quality. Prior to the scan, it's crucial for radiologists and technologists to be aware of the implant to ensure patient safety. The selection of the appropriate MRI suit, optimizing patient positioning, considering MR factors like bandwidth, voxel size, and echo time, and using sequences less prone to metal artifacts also contribute to improved image quality.[28]

3.22. Magnetic resonance imaging (MR) poses challenges due to factors like respiration, GIT peristalsis, intestinal gas metallic effects, and extensive coverage. Artifacts in MR imaging include magnetic field imperfections, motion-related artifacts, and signal sampling methods. Understanding these physics is crucial for identifying trade-offs for improving image quality and reducing artifacts. Techniques like TSE, increasing receiver bandwidth, and overpowering the encoding gradient can mitigate susceptibility effects. Motion artifacts can be addressed through respiratory synchronization, alternative k-space filling patterns, and parallel imaging techniques. Experts must have a comprehensive understanding of artifact causes and potential solutions.[29]

3.23. The article discusses the underrepresentation of panoramic radiography in pediatric radiology literature. It outlines the methodology used, potential defects, and strategies to address them. The authors examine dental, soft tissue, and bone anatomy on panoramic radiographs, focusing on the dental sac and distinguishing it from underlying pathological conditions. They emphasize the importance of a systematic approach to diagnosing mass lesions and performing necessary investigations. They also provide examples of multimodality imaging for relevant pathological conditions and discuss congenital anomalies, specifically dysplasia. [30]

3.24. The article discusses the technical requirements for optimal breast imaging, identifying common artifacts, and reducing them. It emphasizes the importance of a reliable suit, specialized coil, and optimized protocol. It also highlights the need for technologist training to overcome challenges in positioning, FOV selection, and phase encoding.[31]

3.25. The study developed a plan to use free induction decay (FID) as a route finder gating technique in carotid MRI to reduce motion artifacts. The FID-navigator, a modified TSE sequence, was used to assess the effects of gating on image quality. Results showed that gated images had better quality measures than non-gated images, and motion tasks reduced artifacts in non-gated scans. The proposed FID navigator improved image quality.[32]

3.26. The research aimed to calculate abdominal motion as a proxy for liver breathing motion, focusing on respiratory-induced motion (RIM) in liver lesions. A validated learning-based method was developed to estimate RIM of hepatic lesions. The method involved three subjects under MRI scans, using motion data to train regression models. The method was successful with an accuracy of less than 2 mm in mean absolute error.[33]

3.27. This article discusses common MRI artifacts in 3 T clinical neuroradiology, which can mimic pathological conditions and hinder accurate diagnosis. The Siemens 3-T Magnetom Trio system was used for research, with 65% of clinical work focusing on neuroradiology. The authors emphasize the importance of calibration and quality control for accurate results. Recognizing these artifacts is crucial to avoid misdiagnosis and unnecessary treatment, and appropriate techniques can mitigate many of them.[34]

3.28. The research aims to explain the origins and potential remedies for artifacts in MRI exams, focusing on static magnetic field uniformity, imperfect gradient pulses, and nonuniformity in the transmit radiofrequency system. It also discusses the challenges of new MRI techniques, the increasing number of radiofrequency coils, and advanced signal analysis techniques. The paper presents experimental demonstrations and techniques to mitigate artifacts. [35]

3.29. This article provides a picture-centered approach to understanding the physical science behind MRI artifacts, focusing on identifying and understanding the main types of MR artifacts and their underlying principles. It also outlines methods for minimizing image degradation caused by artifacts. The article highlights the importance of understanding the physics of MR imaging in clinical practice, as inadequate image quality can hinder accurate diagnosis. It highlights current technological breakthroughs and practical solutions for addressing artifacts. [36]

3.30. The study investigated the impact of zirconium, titanium, and titanium-zirconium alloy implants on MRI, CT, and CBCT imaging. It found that zirconium implants caused moderate distortion, while titanium and Ti-Zr produced significant artifacts. Ti degree V implants had the least severe artifacts, suggesting that MRI images were less affected. [37]

3.31. The research paper discusses the issue of brain motion artifacts in MRI images and proposes the use of Deep Convolutional Neural Networks (CNN) to automatically detect these artifacts. The study used 68 acquisitions, with 34 motion-free and 34 motion-corrupted, and found that the technique successfully identified motion artifacts in brain MRI, suggesting its potential for large datasets and efficient removal of low-quality images. [38]

3.32. The academic paper aims to rectify respirational artifacts in MRI brain ghosting estimation, a technical challenge in brain imaging. Respiration introduces artifacts in functional MRI movement estimation, creating apparent head motion unrelated to quality degradation. The study found that chest wall motion induced perturbations in the main magnetic field degrade head motion, leading to false perceptions of poor picture quality and artificial fluctuations. Notch filtering can improve head motion estimation accuracy and enhance functional connectivity assessments, ensuring more reliable and precise fMRI analyses. [39]

3.33. The study aimed to identify potential artifacts in dynamic CEST MRI caused by motion and field shifts and explore strategies to reduce them. It found that even slight movements can result in pseudo CEST effects of similar magnitude, especially at clinical field intensities. The findings highlight the importance of addressing motion and field shifts to ensure accurate interpretation of dynamic CEST imaging data, especially in participants with lesions. [40]

4. Material & Method

4.1 Study type

The study was performed at the March Imaging & Diagnostic Center, employing a 1.5 Tesla Symphony MRI system. The study, which covered the months of August 2023 and March 2024, was carried out prospectively. All participants provided their informed consent prior to the study, ensuring their understanding and agreement to participate.

4.2 Study design

This study follows a prospective quantitative observational design, focusing on MRI artifacts and the strategies used to correct them. The study includes all patients who were scheduled for MRI examinations at our department for various clinical reasons. The aim is to collect data on different types of artifacts and evaluate the effectiveness of corrective strategies. All MRI examinations were conducted by a skilled technologist. Whenever artifacts were observed during the examinations, their specific parameters were documented, and appropriate corrective measures were applied.

4.3 Study area

The patients referred to MR imaging at March Imaging & Diagnostic Center will be taken for the study.

4.4 Sample size

Based on how many artifacts are seen in the MR imaging, the sample size for this study will be chosen. An estimated range of 200-250 patients referred for MRI will be included in the study.

4.5 Selection criteria

4.5.1 Inclusion criteria

- All patients who ordered for MRI will be included in this study.
- The patients of all genders (male/female/other).

4.5.2 Exclusion criteria

- Scans that do not show any artifacts are excluded.

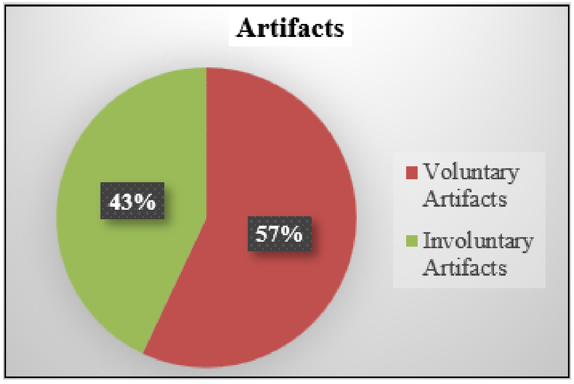
5. Result

We conducted a study involving a cohort of 169 patients, consisting of 88 females and 81 males, who were advised to department of radio diagnosis, for MRI investigation of different body regions. The total artifacts identified were 216 in 169 patients. The most common artifact observed was motion artifact in 120 (55.56 %). These motion artifacts are mostly encountered while imagining moving body parts like the heart, lungs, and abdomen which leads to physiological movements please stop. The moment artifacts are also seen in the uncooperative patients please stop the second most common artifact was Gibbs artifact occupies 43 (19.91%) artifacts which were caused by the fast Fourier transformation concept. The least artifacts are shading artifacts, superior sagittal sinus artifacts, and signal loss and coil error. Most of the artifacts are seen in the brain studies that were in 98 patients. Least artifacts are seen in scrotal, urography, venography, Brachial plexus, and face in 9(4%) patients. The occurrence rates of various artifacts were presented in a tabular format in Table 5.1.

Table 5.1: Different artifacts were observed and parts and their frequency.

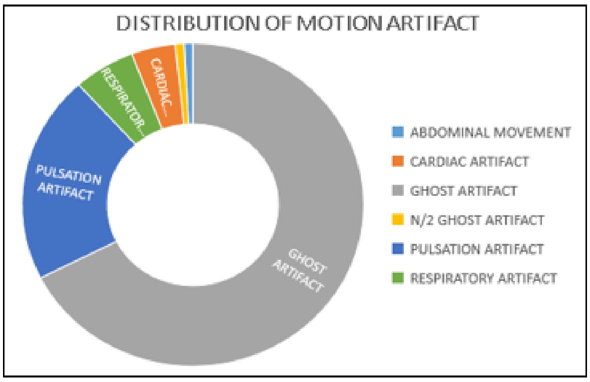
Artifact Type	Count of Artifacts Identified (N)	Percentage (%)	Body Part
Motion Artifact	120	55.56%	Brain, Abdomen, Spine, Joints, Thorax
Gibb's Artifact	43	19.91%	Brain
Cross Talk	20	9.26%	Spine
Magnetic Supectability Artifact	9	4.17%	Knee, Abdomen, Brain
Zipper Artifact	7	3.24%	Brain, Thorax
Zebra Artifact	6	2.78%	Brain
Chemical Shift Artifact	5	2.31%	Abdomen, Spine
Aliasing Artifact	3	1.39%	Brain
Shading Artifact	2	0.93%	Spine, Shoulder
High-Impulse Artifact	1	0.46%	Brain
Grand Total	216	100.00%	

Motion artifacts in medical imaging can arise due to patient movement during the image acquisition process. When the movement is intentional and caused by the patient, it is referred to as a voluntary artifact. On the other hand, involuntary motion resulting from factors like respiration or cardiac motion can lead to artifacts that resemble abnormalities in nearby structures, and these are termed involuntary artifacts. The voluntary artifacts were observed in 123 (57%) patients and involuntary artifacts in 92 (43%) patients. Graph 5.1 presents the distribution of voluntary and involuntary artifacts in terms of percentages.

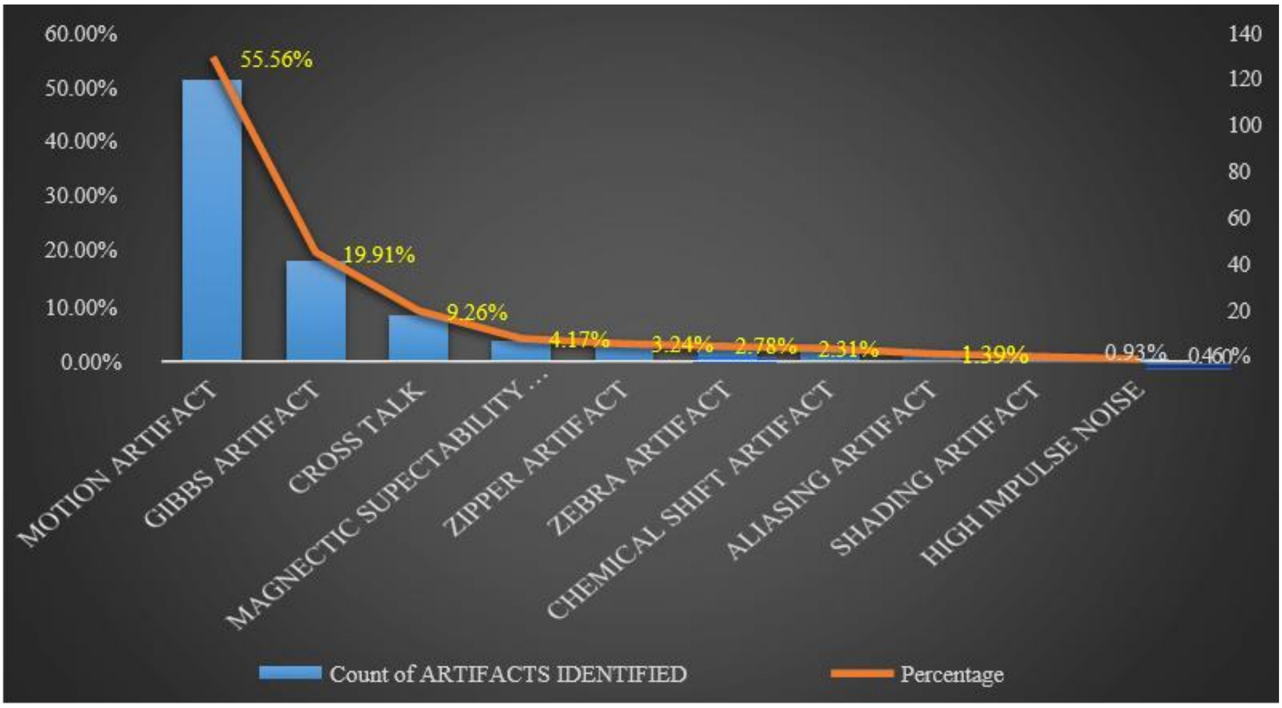


Graph 5.1: Artifacts found on voluntary and involuntary movements

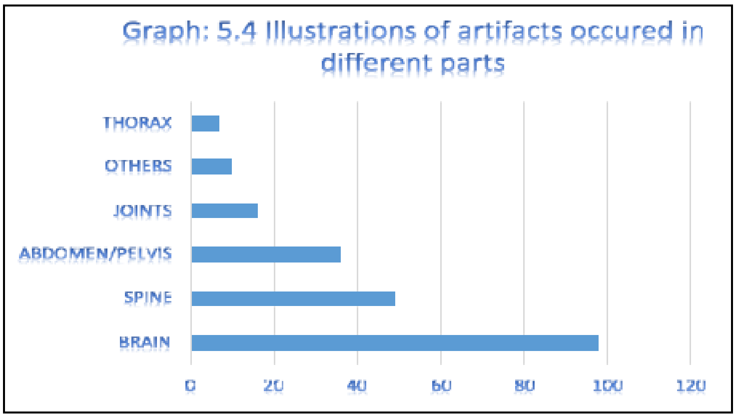
The most common artifact observed was motion artifact in 120 (55.56 %) patients. These artifacts are come across during signal readout process which leads to blurring and ghosting of objects. Types of motions are loosely divided into three categories: elastic movement, flow & rigid body movement. This type of motion results in varying displacements and deformations across different locations within the abdomen. Elastic motion causes bowel movement artifacts, abdominal wall artifacts, cardiac artifacts, and respiratory artifacts. Rigid body motion, also known as bulk motion, involves translations in one or multiple dimensions or completely unrestricted rigid motion. This type of motion does not involve any deformation or distortion. Examples are diaphragm motion and, involuntary head motion. Graph 5.2 showing abdominal movements and cardiac movements which are induced by abdominal wall motion and movements of the heart respectively. Examples are movement of heart, pulsation artifacts of vessels, and brain fluids. [13]. Motion artifacts 55.56%(120) cover the maximum percentage of data, the observed motion artifacts are ghost artifacts 37.50% (81), pulsation artifacts 11.57%(25), cardiac artifacts 2.31%(5), respiratory artifacts 3.24% (7), abdominal movement 0.46 %(1), and N/2 ghost artifacts 0.46 % (1).The motion artifacts are encountered in Brain (41), abdomen (28), spine (24), joints (12), and Thorax (5). The corrective measures of motion artifacts are classified into two: motion prevention and artifact correction. The most typical strategy to prevent motion artifacts in MRI is prevention. Proper instruction of 57% 43% Artifacts VOLUNTARY ARTIFACTS INVOLUNTARY ARTIACTS 33 the patient using short TE sequences, reassuring the patient using the proper coil, performing anesthesia, and using soft pads beside the patient's body and coil. Recommend immobilizing devices such as Velcro straps are among the methods used to mitigate or prevent random motion artifacts. [9]. Artifact correction contains many techniques which are demonstrated in Table -5.2.



Graph 5.2: Displays the data only on motion artifacts.



Graph 5.3: The artifacts observed during the study were analyzed and their frequencies were presented as percentages.



Graph 5.4: Demonstrations of certain aspects of the artifacts were presented. Visual representations or characteristics of the artifacts were provided

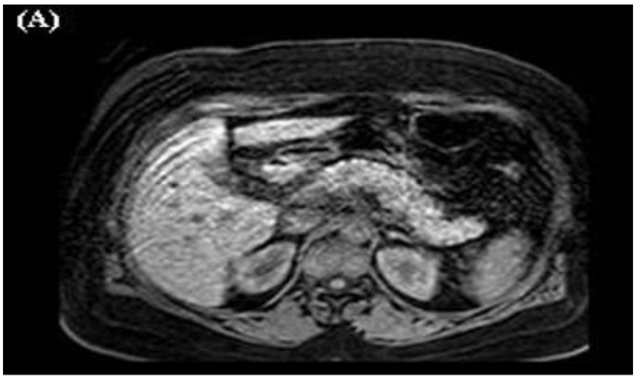


Figure 5.1: Abdominal motion and cardiac artifacts seen in THRIVE sequence.

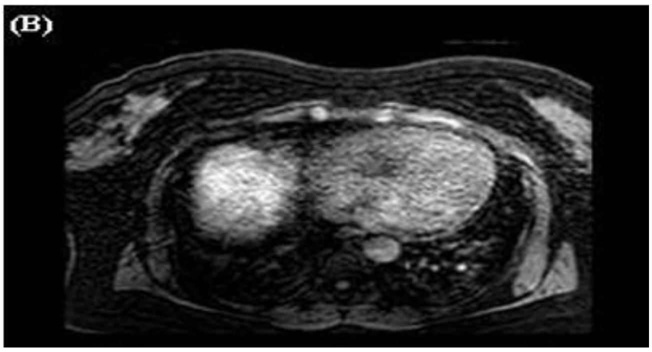


Figure 5.2: N/2 ghost artifact captured in T2W_GRADIENT sequence.

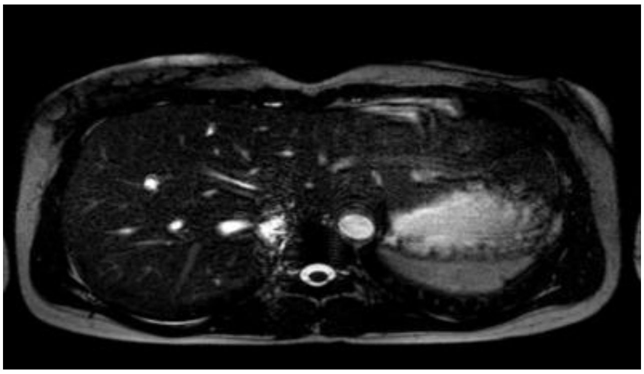


Figure 5.3: Pulsation artifact occurred due to flow in abdominal aorta and inferior vena cava.

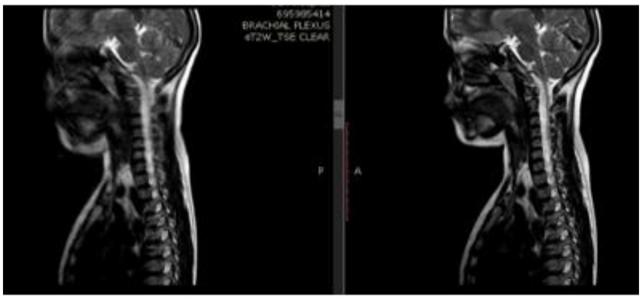


Figure 5.4: Ghost artifact observed which was corrected with assurance and chaperon.

Table 5.2: Illustrates several corrective techniques for motion-related artifacts **[3, 5, 6,8,29, 41]**

Technique	Strength	Weakness
Parallel imaging	Reduces the acquisition time	Increases noise pattern Reduction in SNR
Breath Hold	Motion minimized	Requires patient Compliance
Respiratory Gating and Triggering	Respiratory synchronization	Additional scan time
Signal Averaging (3)	Motion separation	Blurring Additional RF dose
Swapping Encoding Direction	Swap artifacts to another direction	Increases scan time
Saturation Bands	Suppress signals	Additional scan time
Compresses sensing	Accelerated imaging	High Computing requirements
SMS Excitation (Simultaneous multi slice)	Accelerated imaging	Inter slice interference
Radial Imaging (Propeller or Blade)	Motion Robust	Streak Artifact
Cardia Gating	Controls image selection	Increases time
Gradient Moment nulling	Flow compensation	Increases length and TE
Post-processing	minimize the motion artifacts	Decreased image quality

Respiratory synchronization includes breath holding, bellows navigator technique, and phase reordering. Bellows are placed round the subject's abdomen and fastened with a strap to detect variations in lung expansion and contraction associated with chest pressure. Navigator techniques are employed to track respiratory motion by monitoring the movement of the diaphragm. These techniques generate a real-time trace of diaphragmatic excursion, providing a single-dimensional representation of breathing motion. By acquiring images at the end of expiration and reducing motion artifacts, these techniques allow for improved image quality. Phase reordering refers to repositioning the sampling of data in K-space. In this, most negative K-space views are acquired at the completion of expiration (minimal motion) and most positive K-space views are acquired during end inspiration (greatest motion).[29] Gradient moment nulling is referred to as gradient moment rephrasing (GMR) and motion artifact suppressing technique (MAST). 37 The second common artifact observed was Gibbs artifact 19.91 %(43). In this article Gibbs artifact data were not corrected as it is not affecting the anatomy or pathology. Figure shows Gibbs ringing artifact with alternative white and dark lines. Gibbs ringing artifact also known as aka ringing /truncation. Gibbs ringing artifacts unnoticed largely. It appear as dark and white lines (alteration) in MR image. It commonly manifested due to interface between the white matter and CSF. This causes common unless there was an error in the Partial Fourier transformation concept which results in the under-sampling of high spatial frequencies. PF to speed up MRI acquisition and shortens the TE. As a result, there is a decrease in data, which is then reconstructed by performing the inverse Fourier transform (IFT) on limited number of measured data sections, rather than capturing the entire dataset. Restoring fully sampled k-space data with PF reconstruction algorithms like Margosian and Projection onto Convex Sets (POCS) methods is one popular and simple method for artifact removal. Increasing matrix size, recommend smoothing filters and fat suppression technique. [8, 17]

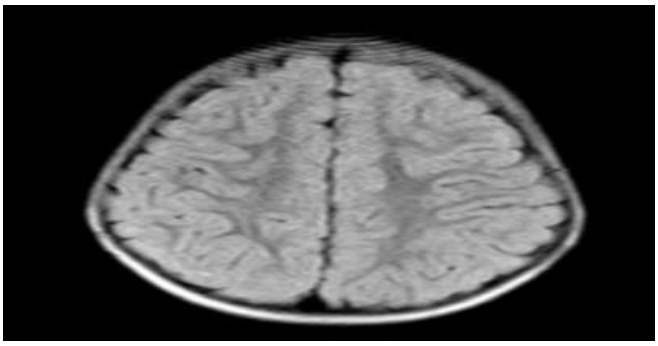
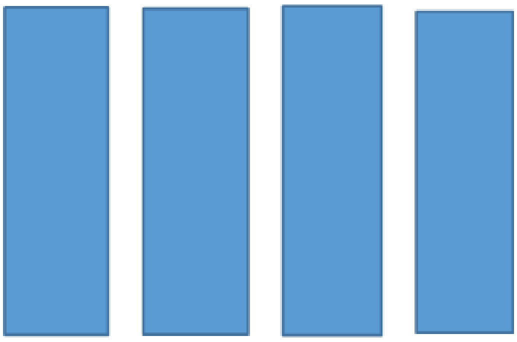


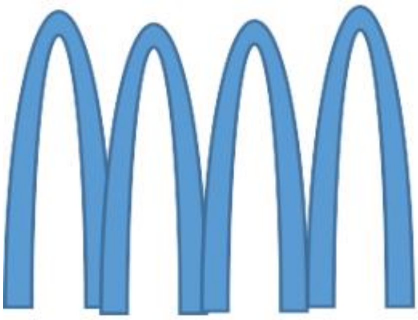
Figure: 5.7 In the axial FLAIR MR image, truncation artifacts resembling ripples can be observed in the frontal high parietal region of the brain. These artifacts are caused by a sudden change or discontinuity in signal intensity.

Cross talk is another common artifact which is observed in 9.26% (20). These artifacts often occur during the planning of axial sections of the lumbar spine and optic nerve. The linear method and the interleave method are two scanning techniques that are used in an MRI scan to capture the signal from a slice as an image is being created. Diagrammatic approach illiterate in figure 5.5 The interleave approach is mostly recommended for increasing SNR. This method produces the signal intensity by acquiring the image in a specific order, either even or odd numbering: slices 1, 3, 5, 7, 2, 4, 6, and 8. Signals emitted by adjacent slices during the acquisition process can lead to cross-talk artifacts on the targeted slice. These artifacts are more commonly observed in axial spin echo T1-weighted images (SE T1WI) compared to SE T2WI because of shorter TR. One way to reduce this effect is by minimizing the intersection angle (using shallow angles) between slices or slice groups. Another method to increase TR. On the other hand, maintaining a distance 25 – 30% slice thickness between slices.



(A)

Figure :5.5 A Displaying the linear acquisition mode.



(B)

Figure: 5.5 B Displaying the interleave method

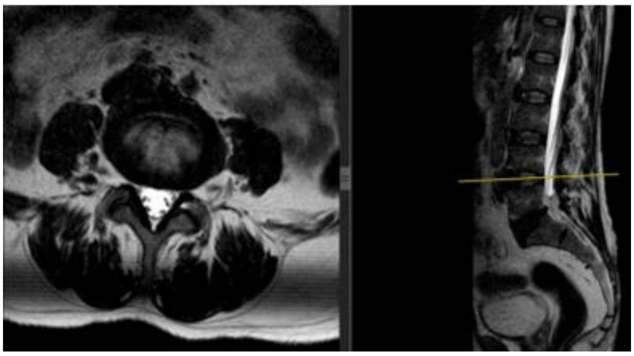


Figure 5.6 Showing cross talk artifact due to slice overlapping in T1w image at the level of L4-L5.

Another common artifact was the magnetic susceptibility artifact observed in 4.17 % (9). It was commonly uncounted when patients consisting of ferromagnetic materials externally or internally. Patients who are referred from orthopedic, cardiac, and dental with respective replacements within. Ferromagnetic materials like shunt, pacemakers, aneurysm clips, screws, plates and grafts which are MRI compatible. [7] MRI friendly metals are titanium zirconium and titanium-zirconium alloy. Even though they are MRI-compatible they cause magnetic susceptibility artifacts by inducing inhomogeneity. How do they induce inhomogeneity? The magnetic field fluctuations occur rapidly, and the magnetization within a single voxel of the imaged object undergoes precession at different rates. This leads to dephasing of protons near to the metal which causes signal loss and distortion of image. [42] These artifacts cannot completely eliminate but they can reduce by using some precious techniques. First Simplest way is proper shimming at region of interest. On other hand, Increasing read out bandwidth for image distortion. Fast spin echo (SE) sequences can be used to mitigate signal loss caused by dephasing. It is important to avoid using fused light bulbs during MRI scans as impurities in the filament can result in artifacts. Techniques such as O-MAR, VAT, and SEMAC are effective in reducing susceptibility artifacts.[45] The table below provides recommendations for improving MR image quality when metallic implants are present.

Table 5.3: Strategies to Minimize Magnetic Susceptibility Artifacts.

Parameters	Adjustment	Effect
Field strength	Decrease	Results in less magnetic field in local cause's heterogeneity.
Read out bandwidth	Increase	Reduces the influence of frequency variations on spatial encoding
Gradient amplitude	Increase	Increases in frequency encoding
Patient position	Distance the device as possible from desirable site	Metal artifact decreases / eliminated
Sequence	MARS like FSE, O-MAR, VAT and SEMAC	Short TR decreases metal artifact

Changes in protocol sequences also extremely useful for dealing magnetic susceptibility artifacts. Some metal artifact reduction sequence (MARS) such as O-MAR, VAT, MAVRIC and SEMAC. VAT (view angle tilting) technique typically reduces in plane distortion artifact it does not correct through plane. This results to blurring of image in this imaging sequence, the gradient is applied with equal amplitudes on the slice selection axis during readout, which helps reduce artifacts caused by metallic implants. Techniques such as SEMAC and MAVRIC (multiacquisition variable resonance image combination) can be employed to improve the visualization and reduce metallic artifacts in the existence of joint implants. Another method called O-MAR combines features from MARS, VAT, and SEMAC to minimize susceptibility artifacts in both the in and through plane directions. [9, 20, 28]

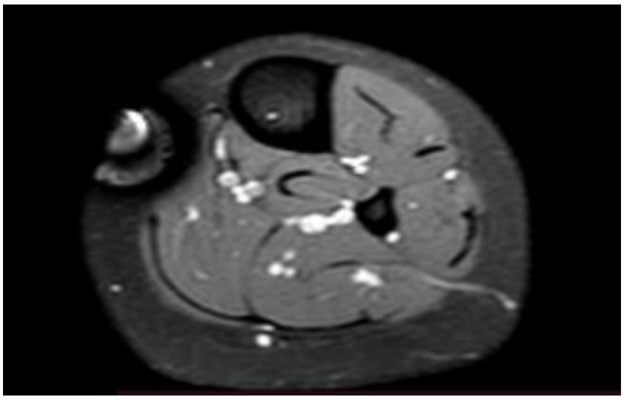


Figure 5.8 Magnetic susceptibility artifact appeared due to bandage pin around proximal end of leg.

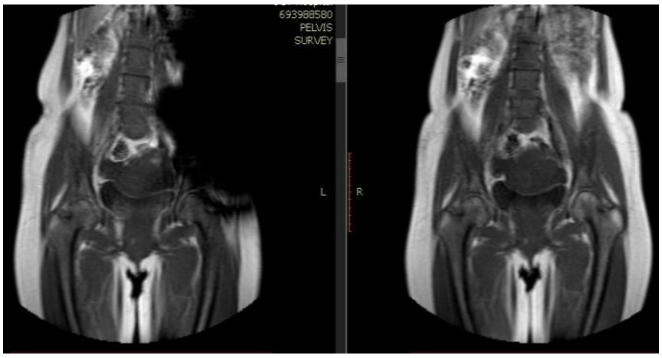
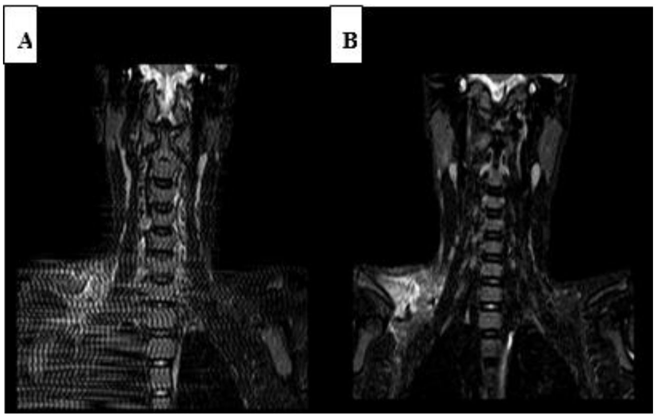


Figure: 5.9 Magnetic supectability artifact appeared due to hook inside salwar later it was corrected by removing the respective cloth

Another artifact encounter in 3.24 % (7) was zipper artifact in different studies such as c spine, brain and thorax . This artifact also called as radiofrequency RF interference. These artifacts occur when radiofrequency waves enter the MRI gantry room and are chosen up by the receiver coil in the frequency encoding direction across the entire series of images. The source of noise are electronic Equipments such as monitoring devices , local RF broadcasting stations, static electricity (cloths, woollen blanket), defective light bulbs in imaging room, imperfect in the faradays cage and ongoing equipment installation near the MR imaging suite [6,11,31] They appear as dark and light lines on MR image. The position depends on frequency of RF source. The overall image is affected by broad wave noise distortion, resulting in decreased SNR and poor picture quality. On the other hand, narrow frequency noise causes linear bands to appear in the image.[29] The artifacts can be eliminated by following measures. Make sure that examination door is close properly. Inspect any damage in the faradays cage for copper seal then respective engineer will be called upon for quality control and quality assurance.[31] identify and removal of source . Correcting the inhomogeneity by two techniques such as shimming and static technique that relays homogenising the flip angle.[12]



Figures: 5.10 RF interference artifact. On coronal STIR MR image series. Linear areas exhibiting elevated signal intensity were observed along the phase-encoding direction. These were caused by external RF noise interference, but the issue was resolved by tightly shutting the gantry room.

Another artifact from same group called zebra artifact/ Moire artifact/ Spike (Herringbone) artifact is a type of phase interface. [31] In high-duty-cycle sequences, such as echo-planar imaging, the application of gradients can result in the presence of spike noise in the acquired data points in k-space. This noise appears as isolated points or a few points with significantly different intensities compared to the rest of the data. When Fourier transformed, the convolution of these spikes with other image information can manifest as dark stripes on the anatomy. The position of the spike in k-space determines the spacing and orientation of the stripes relative to the readout direction. Spike noise is typically transient, but if not addressed, it can become persistent. Loose electrical connections leading to arcs or breakdowns in RF coil interconnections are common sources of spike noise, and it becomes more noticeable in sequences with high duty cycles. [11] . This artifact found in 2.78% (6). Spikes are demonstrated in figure.

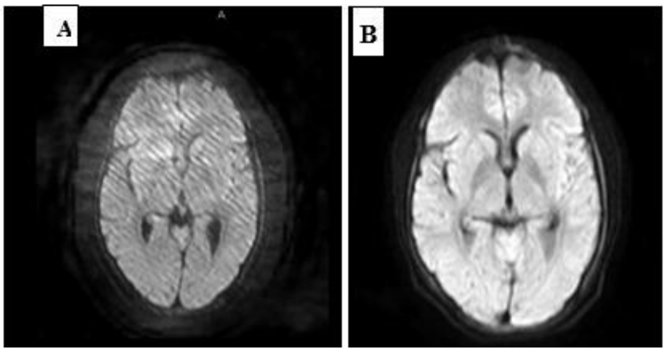


Figure 5.11: The axial diffusion-weighted MR series acquired using a head coil displays distinctive alternating bands of high and low signal intensity, which corresponds to the presence of zebra (moire) artifact

CHEMICAL SHIFT ARTIFACT another MR artifact observed in 2.31%(5) appeared in abdomen . These are commonly seen in abdomen and spine studies . This artifact seen in the T2 weighting sequence. These artifact occurred where there is close relation between water and fat content area. The chemical composition of fat and water are different therefore they have different Larmor frequency due to electromagnetic shielding (local magnetic field) by the molecule. The difference between the larmor frequency is called Relative frequency shift. These artifacts are also useful in some cases like to demonstrate the contents (fat, water) of lesion or organs .Chemical shift artifact are two types. Chemical shift type I and Chemical shift type II.[6] Type one artifact occurs in the frequency and readout encoding direction in non-echo planar imaging. At higher field strengths, the spatial misalignment caused by chemical shift becomes more pronounced due to the increase in the Larmor frequency, which determines the resonance of particles in a magnetic field. The frequency shift results in a dark border at one fat interface and a bright border at the other interface in the frequency encoding direction, where signal frequency determines spatial position. The first kind of chemical shift artifact is this phenomenon. The specific spatial variation is additionally determined by both the bandwidth and the matrix. EPI sequences exhibit significant chemical shift between fat and water protons due to their low bandwidth. By choosing the proper pixel matrix and bandwidth parameters, the size of this effect can be changed. The difference in precession frequency between fat and water at 1.5T and 2.2T is roughly 3.5 ppm.

"Chemical shift Type II artifact is also called as Black boundary artifact and India ink artifact" which generally seen in GRE imaging. This anomaly occurs when both fat and water are present within a single voxel and is characterized by a dark boundary that outlines the interfaces between the two. This is due to variations in the precession frequency of protons in fat versus water, resulting in a buildup or cancellation of phase difference between the two substances as a result of chemical shifts. .[5,29] The principle to eliminate artifacts are Increase pixel size with constant FOV (reduces resolution) ,Increase receiver BW (reduces SNR), Use Fat suppression/Inversion recovery, Choose long TE and Change phase and frequency encoding direction.

Aliasing artifact is another MR artifact observed in 1.39% (3) appeared in spine and brain Examinations . Aliasing artifact also known as Wraparound artifact, Phase wrap arifacts. Aliasing artifacts can appear when anatomical structures that are outside the field of view are portrayed at the other end of the image. This artifact appears when the FOV of encoding is smaller than the imaging anatomy. The occurrence of aliasing artifacts is attributed to under sampling in the k-space. When the signal is inadequately sampled or under sampled, the FFT cannot accurately map the signal in image space. If only every other line of the k-space is sampled, the smaller k-space is duplicated and the field of view is reduced, leading to the presence of aliasing artifacts. To eliminate this artifact, the field of view can be increased, saturation bands can be arranged around the field of view, or the encoding direction can be modified. GRAPPA or SENSE are employed to synthesize the missing lines from under sampling in the k-space and effectively eliminate the aliasing artifact. To prevent aliasing, it has been suggested to decrease the FOV by using extra spoiling gradients between slice selections and read out pulse.[29,31]

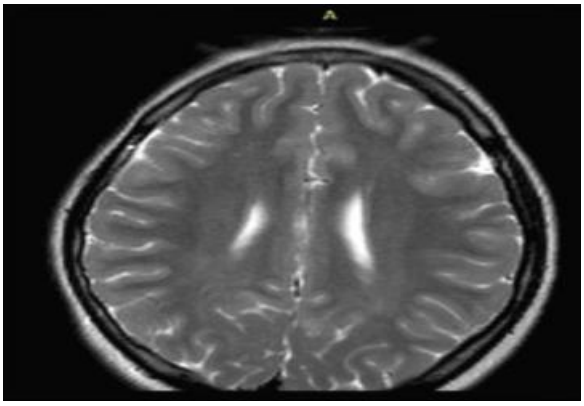


Figure 5.12. Aliasing artifact visible in T2 w axial image of C spine.

Shading artifact observed in 0.93% (2) Intensity gradient artifacts, commonly referred to as shading artifacts, arise from non-uniformity in the RF field. The consequences of these artifacts include decreased brightness, uneven contrast, and a decline in overall image quality. Unevenness in the reception field leads to inconsistencies in image shading due to variations in signal sensitivity of the receiver across the patient's body. Surface coil intensity correction is a method used to address this issue by adjusting the image using a low-resolution version of the same image. This correction takes into consideration the variations in intensity caused by the use of surface coils. By comparing the low-resolution version with the original image, the necessary corrections can be applied to ensure consistent and accurate intensity across the entire image. One possible solution to shading artifacts is to employ an enclosing coil or larger surface coil. Additionally, promote Shimming. In cases where these artifacts arise, it is recommended to switch to a different coil rather than persisting with the one that was initially used. Surface coil intensity correction can also be implemented to address these issues. [3,25]

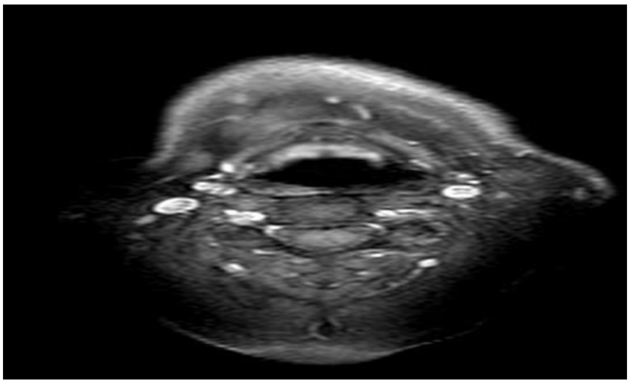


Figure 5.13. Picture showing shading artifacts in T1 axial of neck study

Salt and pepper noise reported in 0.46% (1) appeared in brain, also known as High impulse noise. The artifact manifests as numerous black and white pixels distributed throughout the image. These artifacts arise from sensor malfunctions in image acquisition devices or sudden and sharp disruptions in the image signal, resulting in a degradation of image quality. To address this issue, researchers have developed various algorithms to mitigate the impact of impulse noise and remove these artifacts from the image. There are many denoising methods have been proposed like mean filtering, neighborhood filtering, wiwnwr filtering, but they have disadvantage of blurring edges. These artifacts can be detected and removed by standard median filter. The affected pixels are identified and replaced with an estimated value using a median filter. This technique improves the quality of the noisy image by uniformly moving a filtering window across the image and replacing each pixel with the median value calculated from the pixels within the filtering window. The median filter effectively restores the image by reducing the impact of the corrupted pixels and enhancing overall image clarity.[44] high impulse noise is demonstrated in fig. 5.14.

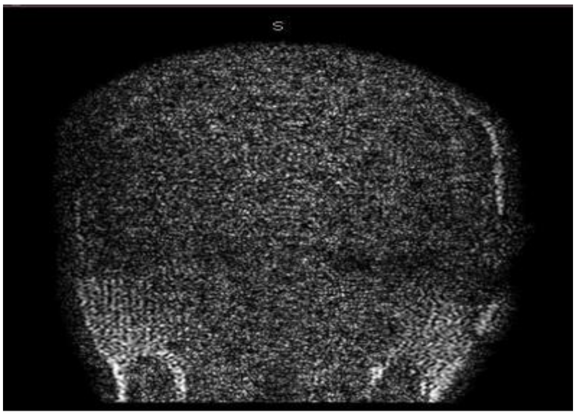


Figure 5.14: Salt and pepper noise appeared in T2 tse coronal

The occurrence of various artifacts and their distribution across different areas were documented and presented in a tabulated format in Table 5.1. The table provides an overview of the frequencies at which different artifacts occurred and in which specific regions they were observed. Additionally, corrective strategies for motion artifacts and magnetic susceptibility artifacts were identified and documented in Tables 5.2 and 5.3, respectively. These tables outline the approaches and techniques employed to mitigate and address the specific types of artifacts encountered during the study.

6. Discussion

This article illustrates MRI artifacts, which are disturbances in the MRI image that can result in inaccurate diagnoses and treatment. The most common type of MRI artifact is motion artifact which is caused by patient movement during the scan. Gibbs artifact, caused by the fast Fourier transformation concept, is another common artifact. Other types of artifacts include shading artifacts, high impulse noise, aliasing artifacts, zipper line artifact, metallic artifact, cross talk, and zebra artifact. A comprehensive analysis was conducted on a group of 169 patients of different anatomical regions. We identified a total of 216 artifacts. with motion artifacts being the most common type, accounting for 55.56% of all artifacts, which also identified motion artifacts as the most common type of MRI artifact in MRI.

Parry et al. (2019) The article analyses MRI artifacts, including motion, Gibbs, and susceptibility, and discusses potential solutions. It emphasizes patient preparation, immobilization, parallel imaging techniques, motion correction algorithms, and high-performance hardware. It also discusses phase correction and gradient moment nulling techniques for susceptibility artifacts. However, it lacks extensive discussion on potential effects.[7]

Zaitsev et al (2016) The article highlights the need for continuous research and innovation to improve image quality and reduce the impact of motion artifacts, presenting detailed analysis and corrective measures.[13]

Lee et al. (2021) The article explores the RPG method, a novel technique for removing Gibbs ringing artifacts, but also highlights its limitations, such as less effective removal and longer processing times. **The study by Singh et al. (2014)** The authors discuss artifacts caused by hardware issues, patient movement, and magnetic field errors, and recommend corrective measures like MRI protocols, image post-processing techniques, and equipment maintenance, while also discussing new MRI technology developments.[9]

Smith and Nayak et al. (2010) The study highlights MRI expertise while concentrating on enhancing fat suppression in MRI utilizing the MAVRIC approach; nevertheless, results are not validated by clinical data.[3]

Budrys et al. (2018) and Heiland S. et al. (2008) The article provides an overview of common MRI artifacts and their corrective approaches, aiming to improve medical professionals' understanding of their origin and impact on diagnostic image quality. However, it primarily focuses on brain artifacts and lacks detailed explanations of technical aspects of MRI, excluding hardware-related techniques. [8,6]

Lee et al. (2021) and Hargreaves et al. (2011) The article aims to raise awareness of MRI artifacts among healthcare professionals, focusing on their physics and mechanisms, but lacks practical guidance for mitigating them. [17,42].

Stadler et al. (2007), Zhuo & Gullapalli et al. (2006), and **D.R. Singh et al. (2017)** aim to present a comprehensive range of artifacts that can appear in MRI. Their studies offer insights into various types of artifacts and contribute to our understanding of their occurrence and characteristics in MRI scans. The article aims to educate radiologists and technicians on the various causes of these artifacts, including hardware and software issues, patient-related factors, and motion-related artifacts. Additionally, the authors provide examples and images of various artifacts and discuss methods to reduce or eliminate them. [5,11,25].

The article emphasizes the need to improve MRI diagnostic accuracy by minimizing artifacts, such as motion, Gibbs, shading, high impulse noise, aliasing, zipper line, metallic, cross talk, and zebra artifacts. Corrective measures include patient education, scanner hardware adjustments, and image post-processing techniques.

There are two limitations to be consider, Firstly, this article primarily focuses on technical aspects of MRI artifacts and corrective measures, neglecting the potential impact of patient-specific factors on the occurrence of MRI artifacts. The presence of artifacts can be influenced by various parameters includes age, body mass index, and underlying medical conditions. These factors may have an impact on the likelihood or frequency of artifacts occurring during imaging procedures. Lastly, the article ignoring potential alternative approaches such as the use of motion correction software, and image analysis tools.

7. Summary

This research article provides recommendations and considerations to reduce the occurrence of artifacts and accelerate picture quality. The article suggests several measures that can be taken to achieve these goals.

a) **Patient preparation:** Proper patient preparation is essential to minimize the occurrence of motion artifacts. Patients should be instructed to remain still during the scan and given clear instructions on how to control their breathing. Patient comfort should also be prioritized to reduce involuntary movement.
b) **Scanner hardware:** Regular maintenance and calibration of scanner hardware. Regular quality assurance checks and software upgrades
c) **Image post-processing:** Post-processing techniques such as image smoothing, filtering, and artifact correction algorithms.
d) **Advanced imaging techniques:** Innovative imaging techniques like DWI and fMRI have the potential to enhance diagnostic precision by offering comprehensive insights into tissue structure and functionality. These advanced approaches enable a deeper understanding of the underlying physiological processes, leading to improved diagnoses.
e) **Patient-specific factors:** Thorough assessment of individual patient factors, including age, body mass index, and pre-existing medical conditions, can contribute to reducing the likelihood of artifacts. Considering these patient-specific factors allows for better optimization of imaging parameters and protocols, leading to improved image quality and artifact mitigation.
f) **Continuous improvement:** Collaboration between researchers, clinicians, and industry partners can help to identify new approaches to improve imaging quality and reduce artifacts.
g) **How AI can correct MRI artifacts in the future:** By identifying and fixing MRI artifacts, artificial intelligence (AI) can enhance image quality and lessen the need for repeat scans. While Generative Adversarial Networks (GANs) and physics-informed neural networks can produce images free of artifacts, deep learning-based techniques can identify certain MRI artifacts. Deep learning-based reconstruction and compressed sensing methods can enhance image restoration and reconstruction. AI-powered MRI protocol optimization can be used to correct artifacts in real time. Developing quantitative imaging methods, creating tailored treatment regimens, and combining MRI with other imaging modalities are some future possibilities.

8. Conclusions

MRI can pose significant challenges in diagnostic imaging, but with proper knowledge and measures, they can be minimized. Radiographers must continually adapt medical imaging parameters and conditions to achieve optimal results. A universal correction tool is not available for all artifact types, but a toolbox of techniques with specific parameters can enhance accuracy. Different correction methods or strategies may be employed depending on the artifact's nature and imaging challenge. Clinicians can improve patient care by implementing patient preparation, scanner hardware, advanced imaging techniques, image post-processing, patient-specific factors, and continuous improvement in research results.

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