MR ARTIFACTS

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ABSTRACT

BACKGROUND
Artifacts in MRI image are produced as a result of various factors related to the machine and the subject undergoing MRI. Artifacts not only affect the quality of images, but also lead to misinterpretation of images by mimicking the pathology. Thus the purpose of this article is to help the radiologist be aware of the most common types of artifacts in day-to-day practice, explain in short the physics related to the appearance of artifact and practical steps to reduce or eliminate the artifacts. Imaging in MRI machine is subjected to various types of artifacts. Artifacts lead to diagnostic dilemma and degradation of the image quality. Hence, it is necessary to understand the type of artifact and measures taken to minimize or eliminate the same. Understanding the artifacts is a three step process, firstly knowing about the type of artifact, secondly cause behind it and thirdly how to decrease or remove the artifacts.

MATERIAL AND METHODS
Indicated cases for MRI imaging with different protocols and sequences depending upon the need were performed at MAAX super speciality hospital an associated hospital of Subbaiah Institute of Medical Sciences, Shimoga with GE 1.5T MRI using conventional 2D and 3D Fourier transform sampling methods and performing the standard sequences mentioned in the image.

RESULTS
Day to day MRI indicated patients were scanned on 1.5 T MRI with different protocols and sequences later on acquiring these images showed varied artifacts these were characterized and classified later proper correction in protocol, sequences, by adding appropriate filters, adjusting the field of view and by counseling eliminating/reducing the artifacts and thus deriving a proper clinical interpretation.

CONCLUSION
Grouping the artifacts simplifies the understanding of the cause of artifact. The article also describes the nature of the imaging appearance and simple measures required to reduce or correct the artifacts. It will help the radiologist improvise the quality of the images and have a clear difference between pathology and an artifact.

KEYWORDS
MR Artifacts, Geometric Distortion, Phase Encoding, Frequency Encoding, Parallel Imaging.

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BACKGROUND

Artifacts in MRI image are produced as a result of various factors related to the machine and the subject undergoing MRI. Artifacts not only affect the quality of images, but also lead to misinterpretation of images by mimicking the pathology. Artifacts may cause confusion in the diagnosis. Artifacts are commonly seen as a part of daily imaging methods. Knowing the source of artifacts helps to correct the artifact and obtain a clear and unambiguous image.

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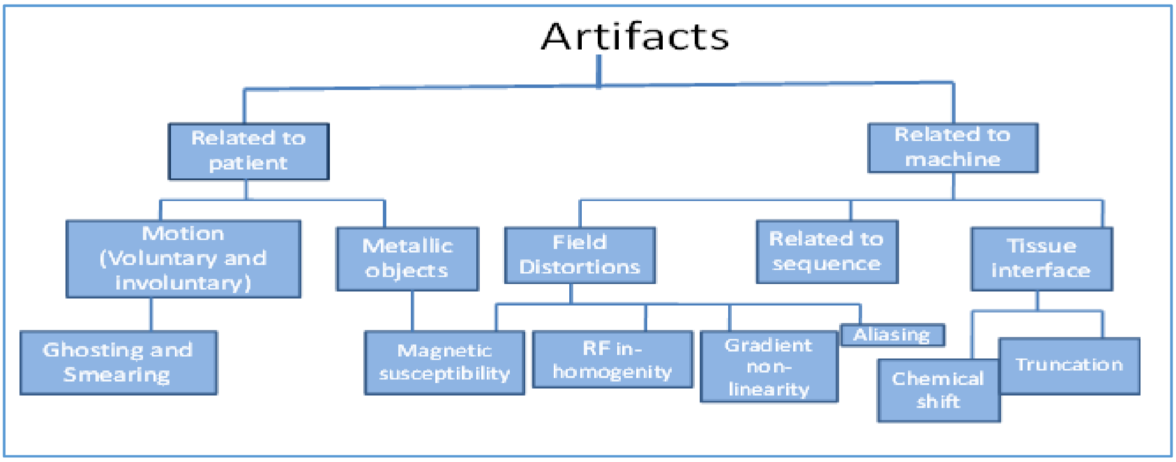
New machines are provided with auto-correction techniques which minimize the occurrence of the artifacts.

However, not all artifacts can be corrected. Some artifacts can merely be eliminated by altering the imaging parameters, whereas some just reduce in intensity. There are some artifacts which help in imaging diagnosis to understand the nature of the lesion, for example chemical shift artifact to demonstrate fat-soft tissue interface. Some artifacts cannot be corrected, for example artifacts caused due to metallic foreign bodies like prostheses and implants. Understanding the nature of artifacts requires in depth knowledge of the physics so that appropriate measures are taken to rectify the image. Artifacts are different in 1.5T and 3T machines. Thus the purpose of this article is to help the radiologist be aware of the most common types of artifacts in day-to-day practice, explain in short the physics related to the appearance of artifact and practical steps to reduce or eliminate the artifacts. To help radiologist have a basic perspective about the artifacts, we have grouped them. Below is the chart showing various groups.



MATERIALS AND METHODS
All the images were obtained at MAAX super speciality hospital, Shimoga an associated hospital of Subbaiah institute of medical sciences with GE 1.5T MRI using conventional 2D and 3D Fourier transform sampling methods and performing the standard sequences.

RESULTS
Indicated patients were scanned on GE 1.5 T MRI depending upon the need different protocols and sequences were used later on acquiring images showed varied artifacts, these were characterized and classified based on patient and machine; most common artifacts so produced were motion artifacts, metallic artifacts, ghosting artifacts, aliasing artifacts, RF inhomogenity, smearing of images, truncation or ringing artifacts, chemical shift artifacts and zipper artifacts these said artifacts were identified and proper correction in protocol, sequences and counseling the patient as detailed in the discussion thus deriving a proper clinical interpretation was achieved.

DISCUSSION
We will discuss the nature, related physics and correction methods for few common artifacts;
Artifacts Related to Patient

Motion Artifacts (Figure 1 & 2)
Cause- Voluntary/ involuntary motion like cardiac, respiratory, esophageal contractions, bowel motion.[1,2]
Effect- when the RF pulse is applied during readout at the time of movement, there is shift in the voxel which gives out signal. The resultant effect is ghosting/smearing.[1] of the image. Artifacts occur in the phase encoding direction.[3]
Correction
Voluntary Motion
- Patient counseling as regards to the breath-hold/ swallowing.
- Sequences with less acquisition times such as HASTE.
- Parallel imaging techniques which dramatically reduces the scan time.

Involuntary Motion.[1,4]
- Respiratory gating (increases the acquisition time).
- Respiratory compensation methods (like ROPE- Respiratory ordered phase encoding and COPE without increasing the acquisition times.[5,6]
- Cardiac Gating
- ECG gating
- Saturation Bands for esophageal contractility.

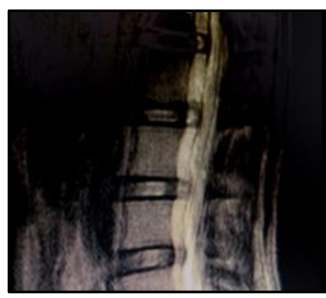


Figure 1. Motion Artifacts

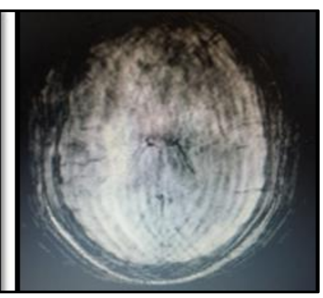


Figure 2. Ghosting Artifacts

Metallic Foreign Bodies (Figure 3)
Cause- Metal objects result in in-homogenous static magnetic fields thus causing signal loss due to dephasing of the precession photons. These are more intense in 3T imaging than 1.5T.[7,8]
Effect- Signal loss at the implantation and geometric distortion of the adjacent imaging field and also may result i9n incomplete fat suppression.[9]
Correction- Artifacts could not be eliminated, but its intensity can be reduced to some extent.
- Metal artifacts reduction technique consisting of reducing slice thickness, increasing the sample bandwidth and read gradient with angle tilting.[10]
- Using standard spin echo sequences.[11]
- Using smaller voxels.
- Short TE images with increase in sample bandwidth.

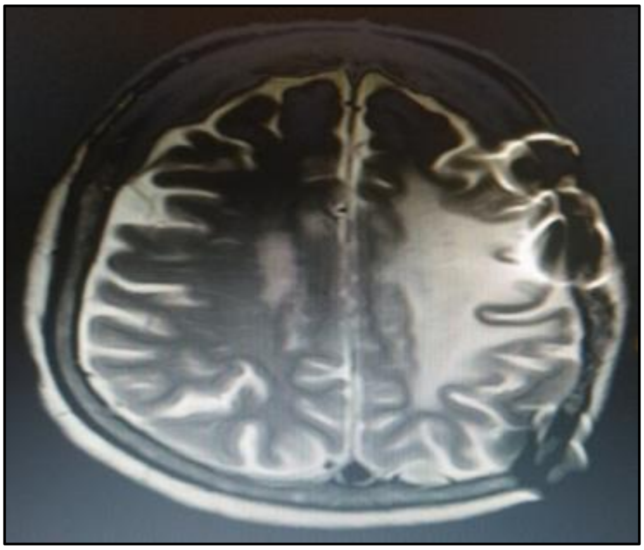


Figure 3. Metallic Artifacts

Flow Related Artifacts (Figure 4 and 5)
These are type of motion artifacts related to the CSF/ blood vessel pulsations.

Cause
These artifacts are seen when the protons lack the initial and the subsequent RF pulses.
Effect: There is loss of signal at the given point.

Correction
- Use of thick slices
- Short TE
- Imaging plane parallel to the direction of flow.

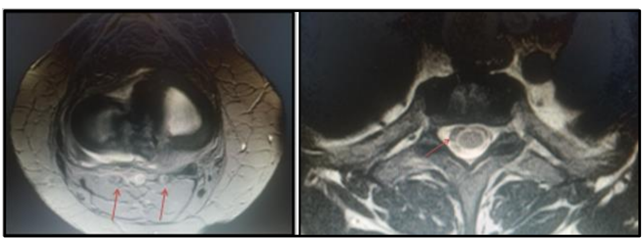


Figure 4 **Figure 5**

Artifacts Related to Machine
Field Distortion Artifacts
Magnetic Susceptibility
Cause- If a diamagnetic or a paramagnetic structure is placed inside the magnetic field, it induces its own magnetic field which may be along the direction or opposite to that of the main magnet. Ferro magnetic structures compared to paramagnetic and diamagnetic results in bigger artifacts.[12]
Effect- Loss of the signal and field distortion.
Correction
- Parallel imaging/ Echo planar imaging: One factor responsible for magnetic susceptibility is long echo train lengths. Parallel imaging has short echo train length hence will reduce the effect of susceptibility.[13]

Gradient Non-linearity[1]
Cause- The gradient coils have limited size and cannot cover the entire field of view. Hence there is gradient fall-off at the edge.
Effect- Geometric distortion at the edge causing shortening.
Correction
- Use of post-processing techniques.

RF In-homogeneity (Figure 6)
Cause- due to non-uniform RF coils or non-uniformity of the receiving coil.[14] Commonly occurs in body imaging. The effect is more pronounced in 3T machines.
Effect- Non-uniform signal for e.g. incomplete suppression of the fat.
Correction
- Using RF Shimming.
- Using STIR sequence for fat saturation.

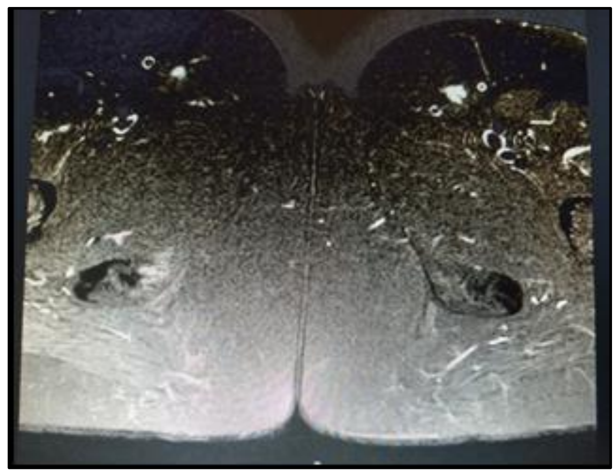


Figure 6. Incomplete Suppression of Fat

Aliasing[1,4,15] (Figure 7)
Cause- When frequency (more than the nyquist frequency) protons are sampled outside the field of view (FOV), the receiver RF coil falsely relocates them as lower frequencies in a reconstructed image. This artifact occurs in the frequency encoding direction.
Effect- Folding of the image causing wraparound/aliasing. The image outside the FOV is folded and placed within the FOV.
Correction
- Using larger FOV.
- Increasing the bandwidth.
- Reverse phase and frequency encoding direction.

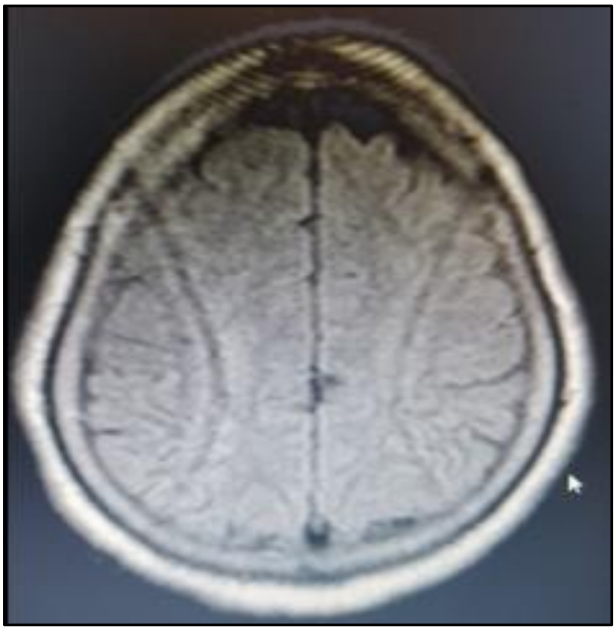


Figure 7. Aliasing Artifact

Zipper Artifact[16] *(Figure 8)*
Cause- The MR signal is contaminated by RF noise due to breach in Faradays cage or faulty equipment inside the room.
Effect- Alternate black and white lines mimicking a zipper.
Correction

- Find out the source of RF leak and take corrective measures.

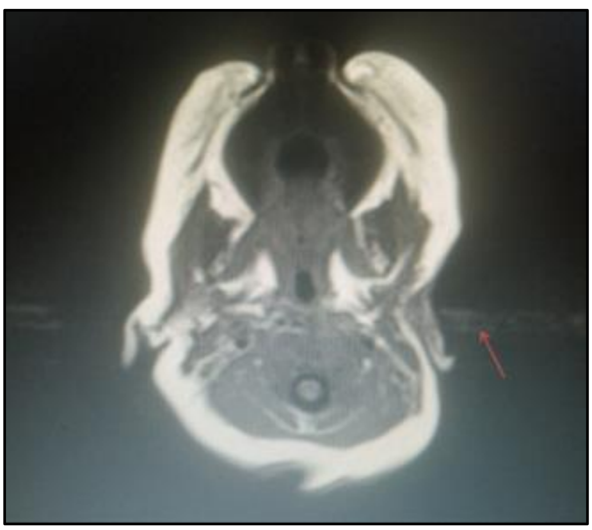


Figure 8. Zipper Artifact

Artifacts Related to Sequences
Diffusion Sequence
Magnetic Susceptibility Artifacts
Usually occurs at the bone tissue interface.
Eddy Current Artifact (Figure 9)
Cause- During the read out, the signal is affected by switching off gradient coils. Occurs in the phase encoding direction.
Effect- Smearing/distortion of the image.[17,18]
Correction

- Diffusion encoding with bipolar pulse
- Using linear transformation.

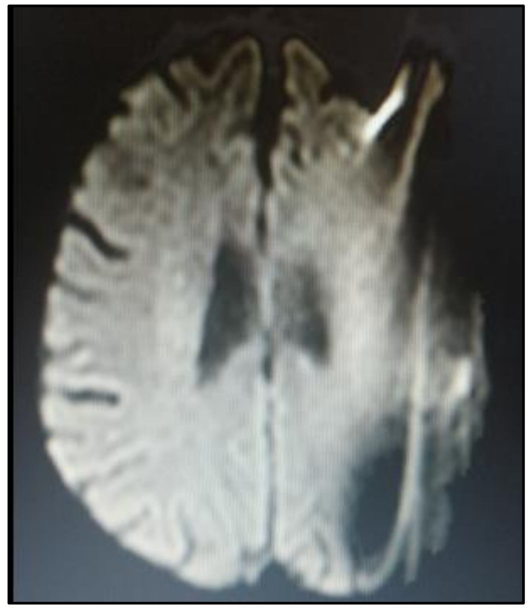


Figure 9. Smearing of Image

Parallel MR Imaging
Image Mismatch
Cause- Type of motion artifact. There is movement between the series. Hence during reconstruction artifact arises as tissue is not there on the same location of next series [19].
Effect: dark and white lines around the tissue interfaces.
Correction

- Avoiding motion.
- Reacquiring the images for calibration.

Chemical Shift artifact[20,21] *(Figure 10)*
Cause- Fat and water precise with different frequencies and hence get registered on different spatial locations. Fat resonates at slightly lower frequency than water. It occurs along frequency encoding direction. Commonly occurs around bladder, orbits and kidneys.
Effect- This results in the band of dark and light signal at the interface.
Correction

- Use of fat suppression.
- Change in phase and frequency encoding directions.

Figure 10. Chemical Shift Artifact

Gibbs (Truncation) Artifact (Figure 11)
Cause- There are number of infinite frequencies at high soft tissue interfaces, which correspond in the image in the form of lines. The artifact is seen in both phase encoding and frequency encoding directions.
Effect- At the interface of high and low signal intensity, there is occurrence of number of closely spaced lines (ripple).
Correction

- Applying smoothing filters.
- Reduce the pixel size.

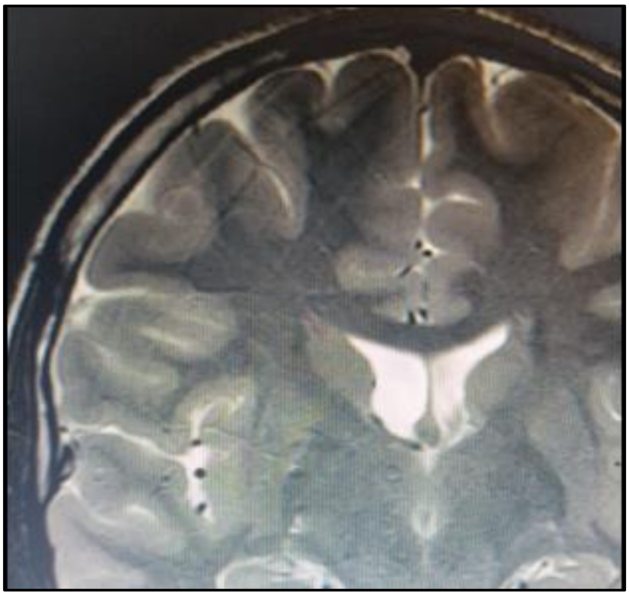


Figure 11. Truncation or Ringing Artifact

CONCLUSION

The article describes the commonest artifacts encountered in the daily practice. Grouping the artifacts simplifies the understanding of the cause of artifact. The article also describes the nature of the imaging appearance and simple measures required to reduce or correct the artifacts. It will help the radiologist improvise the quality of the images and have a clear difference between pathology and an artifact.

REFERENCES

[1] Morelli JN, Runge VM, Ai F, et al. An image-based approach to understanding the physics of MR artifacts. RadioGraphics 2011;31(3):849–866
[2] Hakky M, Pandey S, Kwak E, Jara H, Erbay SH. Application of basic physics principles to clinical neuroradiology: differentiating artifacts from true pathology on MRI. Am J Roentgenol. 2013;201:369–77.
[3] WoodML, Henkelman RM. Magnetic resonance artifacts from periodic motion. Med Phys1985; 12: 143–151.
[4] Zhuo J, Gullapalli RP. AAPM/RSNA physics tutorial for residents: MR artifacts, safety, and quality control. RadioGraphics 2006;26(1):275–297.
[5] Haacke EM, Patrick JL. Reducing motion artifacts in two-dimensional Fourier transform imaging. Magn Reson Imaging 1986;4(4):359–376.
[6] Bailes DR, Gilderdale DJ, Bydder GM, Collins AG, Firmin DN. Respiratory ordered phase encoding (ROPE): a method for reducing respiratory motion artefacts in MR imaging. J Comput Assist Tomogr 1985;9(4):835–838.
[7] Dietrich O, Reiser MF, Schoenberg SO. Artifacts in 3-T MRI: physical background and reduction strategies. Eur J Radiol 2008;65(1):29–35.
[8] Bernstein MA, Huston J 3rd, Ward HA. Imaging artifacts at 3.0T. J Magn Reson Imaging 2006;24(4):735–746.
[9] Hargreaves BA, Worters PW, Pauly KB, et al. Metal-induced artifacts in MRI. Am J Roentgenol. 2011;197:547–55.
[10] Olsen RV, Munk PL, Lee MJ, et al.. Metal artifact reduction sequence: early clinical applications. RadioGraphics 2000;20(3):699–712.
[11] Tartaglino LM, Flanders AE, Vinitski S, Friedman DP. Metallic artifacts on MR images of the postoperative spine: reduction with fast spin-echo techniques. Radiology. 1994;190:565–69.
[12] Lee MJ, Kim S, Lee SA, et al.. Overcoming artifacts from metallic orthopedic implants at high-field-strength MR imaging and multidetector CT. RadioGraphics 2007;27(3):791–803.
[13] Glockner JF, Hu HH, Stanley DW, Angelos L, King K. Parallel MR imaging: a user's guide. RadioGraphics 2005;25(5):1279–1297.
[14] Susie Y. Huang, Ravi T. Seethamraju, Pritesh Patel, et al. Body MR Imaging: Artifacts, k-Space, and Solutions. Radiograpics. September-October 2015; 35(5): 1439–1460.
[15] Harvey JA, Hendrick RE, Coll JM, et al. Breast MR imaging artifacts: how to recognize and fix them. Radiographics. 2007 Oct;27 Suppl 1:S131-45.
[16] Yanasak NE, Kelly MJ. MR imaging artifacts and parallel imaging techniques with calibration scanning : a new twist on old problems. Radiographics. 2014 Mar-Apr;34(2):532-48.
[17] William M. Spees, Niels Buhl, Peng Sun, et al. Quantification and Compensation of Eddy-Current-Induced Magnetic Field Gradients. J Magn Reson. 2011 Sep; 212(1): 116–123.
[18] Graves MJ, Mitchell DG. Body MRI artifacts in clinical practice: a physicist's and radiologist's perspective. J Magn Reson Imaging 2013;38(2):269–287.
[19] Noël P, Bammer R, Reinhold C, Haider MA. Parallel imaging artifacts in body magnetic resonance imaging. Can Assoc Radiol J 2009;60(2):91–98.
[20] Hood MN, Ho VB, Smirniotopoulos JG, Szumowski J. Chemical Shift: The Artifact and Clinical Tool Revisited. Radiographics. 1999;19:357–71.
[21] Bley TA, Wieben O, François CJ, Brittain JH, Reeder SB. Fat and water magnetic resonance imaging. J Magn Reson Imaging 2010;31(1):4–18.
[22] Czervionke LF, Czervionke JM, Daniels DL, et al. Characteristic features of MR truncation artifacts. AJR Am J Roentgenol. 1988 Dec;151(6):1219-28.