KREP 2025

KARNATAKA RADIOLOGY EDUCATION PROGRAM

MRI ARTIFACTS

An MRI artifact is a visual artifact in magnetic resonance imaging. It is a feature appearing in an image that is not present in the original object. Some affecting the diagnostic quality, while others may be confused with pathology. Artifacts can be classified as patient-related, signal processing-dependent and hardware (machine)-related.

Classification of artifacts:

MRI hardware and room shielding

- Zipper Artifact
- Zebra Stripes
- Moiré fringes
- Central Point Artifact
- RF overflow artifact
- Inhomogeneity Artifact
- Shading Artifact
- Aliasing Artifact (also known as wrap around artifact)
- Starry Sky Artifact

MRI software

- Slice-Overlap Artifact (also known as cross-talk artifact)
- Cross Excitation

Patient and physiologic motion

- Phase-Encoded Motion Artifact
- Entry Slice Phenomenon
- Transient Arterial Phase Respiratory Motion-Related Artifact

Tissue heterogeneity and foreign bodies

- Black boundary artifact
- Magic Angle Effect
- Magnetic Susceptibility Artifact
- Chemical Shift Artifact

Fourier transform and Nyquist sampling theorem

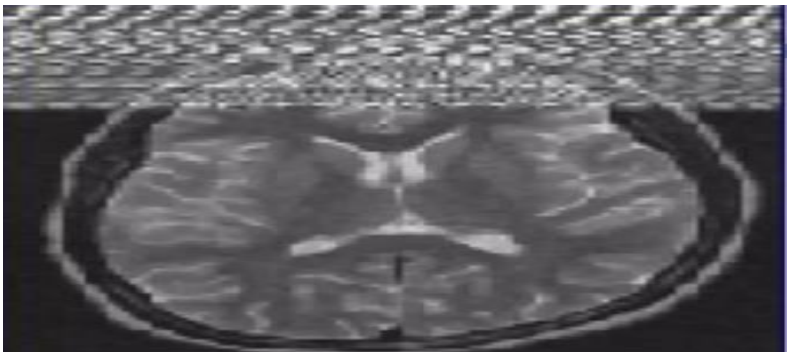
- Gibbs artifact/truncation artifact
- Aliasing/wrap around artifact

1. Zipper artifacts

- These artifacts can be related to hardware or software problems either of the scanner itself or the shielding.
- Common cause is spurious radio-frequency signals contaminating received imaging data. In this instance, the direction in which the artifact is seen depends on the direction in which frequency is encoded and will appear at right angles to the frequency encoding direction.
- The result is an abnormal black and white signal band across the entire image corresponding to that frequency.

Solution:

- Make sure the MR scanner room-door is shut during imaging
- Remove all electronic devices from the patient prior to imaging.

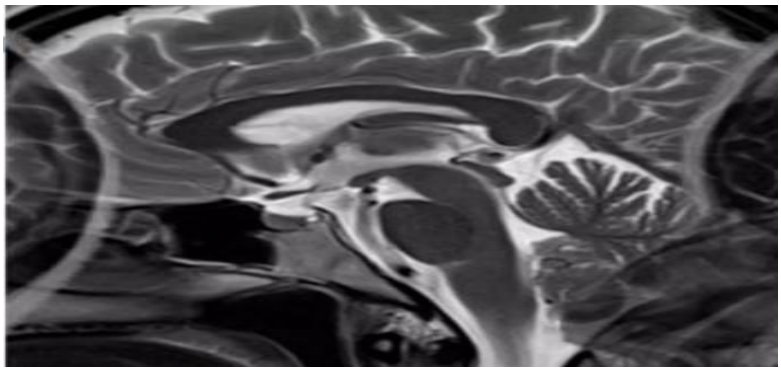


2. Aliasing artifact

- Also known as **wrap-around.**
- Occurs when the field of view (FOV) is smaller than the body part being imaged.
- The part of the body that lies beyond the edge of the FOV is projected onto the other side of the image.
- It is caused by under sampling in the phase encoded direction.

Solution:

- Enlarging the field of view (FOV)
- Using pre-saturation bands on areas outside the FOV
- Anti-aliasing software
- Switching the phase and frequency directions
- Use a surface coil to reduce the signal outside of the area of interest.

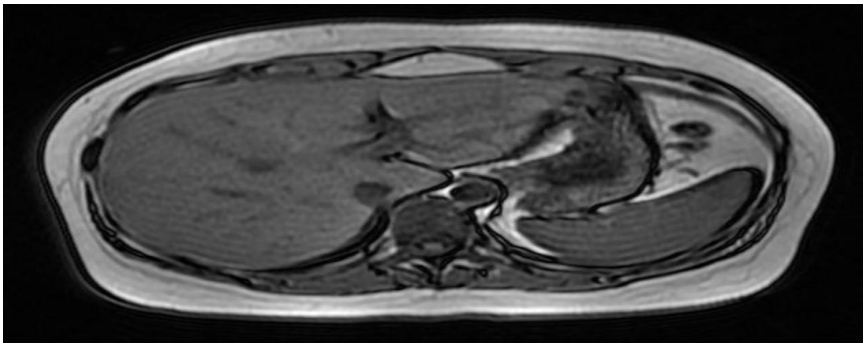


3. Black boundary artifact

- Also known as India ink artifact or type 2 chemical shift artifact
- It is an artificially-created black line located at fat-water interfaces such as those between muscle and fat.
- This results in a sharp delineation of the muscle-fat boundary lending the image an appearance as if someone has outlined these interfaces with ink that is sometimes visually appealing but not an anatomical structure.
- This artifact occurs in gradient echo (GE) sequences as a result of selecting an echo time (TE) in which the fat and water spins (located in the same voxel at an interface) are out of phase, canceling each other.

Solution:

- Choose TEs close to 4.5 ms, 9 ms, 13.6 ms
- Fat suppression can be used
- Use SE sequence instead of GE

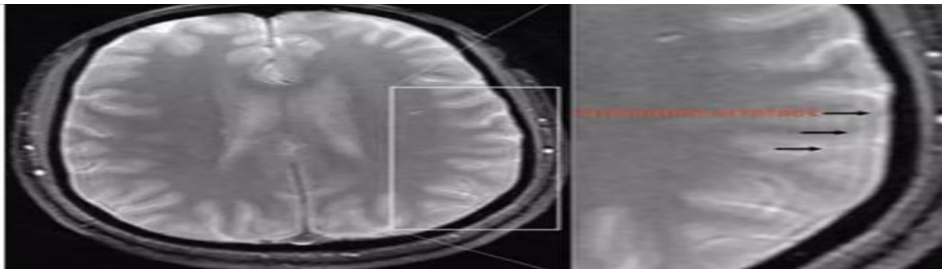


4. Gibbs artifact

- Also known as truncation artifact or ringing artifact.
- Occurs at high-contrast boundaries.
- Due to omission of sampled signals.
- Commonly seen at the low signal in intensity spinal cord with high signal intensity CSF on T2W1 of the spine.
- As the signal is sampled, some data is necessarily omitted in k-space, causing the signal intensity of a given pixel to vary from its ideal signal intensity.
- Appears as bright and dark lines.

Solution:

- Increasing the matrix size.
- Use of smoothing filters.
- If fat is one of the boundaries, use fat suppression.

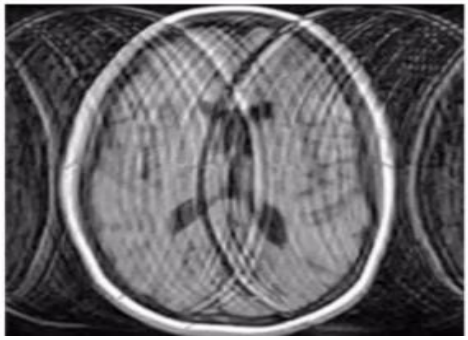


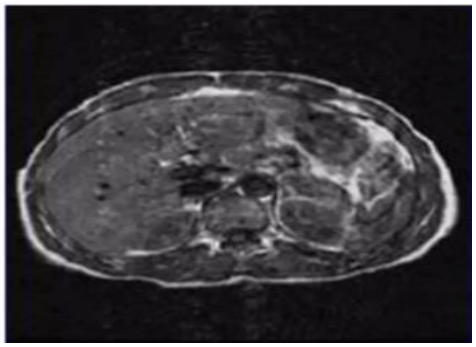
5. Phase-encoded motion artifact

- Occurring as a result of tissue/fluid moving during the scan.
- These artifacts may be seen from arterial pulsations, swallowing, breathing, peristalsis, and physical movement of a patient.
- When projected over anatomy it can mimic pathology, and needs to be recognized.
- Motion that is random such as the patient moving produces a smear in the phase direction. Periodic motion, such as respiratory or cardiac/vascular pulsation, produces discrete.

Solutions:

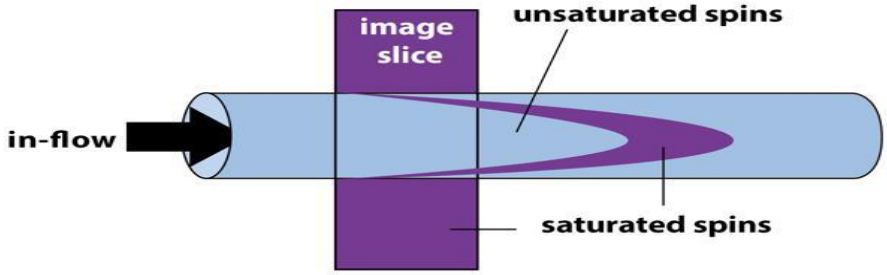
- Cardiac/respiratory gating
- Spatial presaturation bands placed over moving tissues (e.g. over the anterior neck in sagittal cervical spines)
- Spatial presaturation bands placed outside the FOV, especially before the entry or after the exit slice for reducing ghosting from vascular flow: arterial and venous
- Scanning prone to reduce abdominal excursion
- Switching phase and frequency directions
- Increasing the number of signal averages
- Shorten the scan time when motion is from patient movement.





6. Entry slice phenomenon

- Occurs when unsaturated spins in blood first enter into a slice or slices.
- It is characterized by the bright signal in a blood vessel (artery or vein) at the first slice that the vessel enters.
- Usually, the signal is seen on more than one slice, fading with distance.
- This mechanism is used in a positive fashion to generate flight MR angiograms.
- This artifact has been confused with thrombosis with disastrous results.
- Spatial saturation bands place before the first slice and after the last can be used to eliminate this artifact.

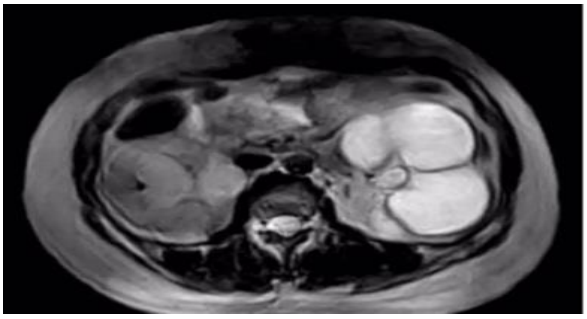


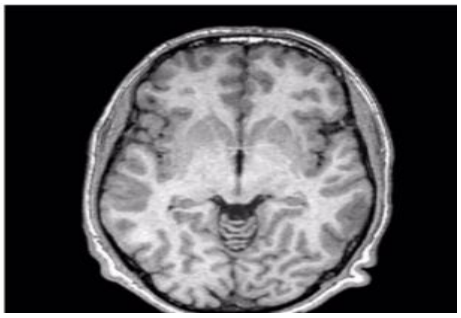
7. Inhomogeneity artifact

- It is a type of magnetic resonance imaging artifact that occurs due to multiple factors, such as irregular anatomical area (for example, shoulder, hips, ankles), presence of metallic objects or inhomogeneity of the main field.
- The inhomogeneity artifact appears as hyperintense or high signal in some fat-suppressed sequences that depend on the main field (i.e. SPIR or SPAIR).
- The main problem with this artifact is that it can simulate edema or subcutaneous cellulitis. The use of sequences that do not depend on the homogeneity of the main magnetic field is highly recommended.

Solution:

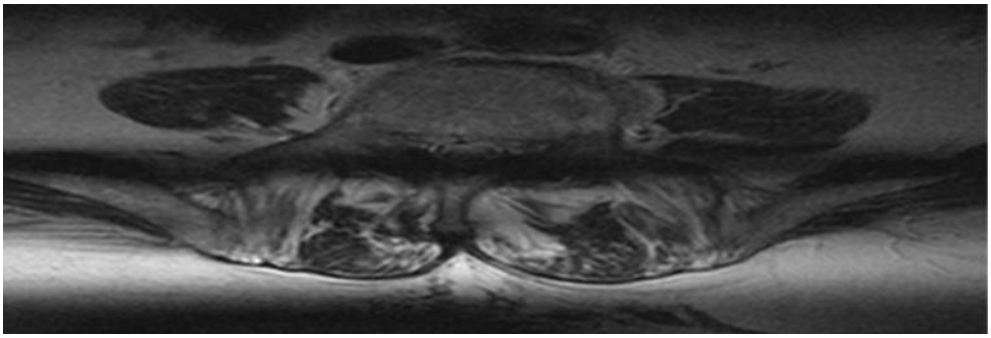
- Can be fixed by using shimming coils in exam planning (at the center of FOV acquisition)
- Checking patient and MRI gantry before starting the exam, removing metallic elements or items with magnetic susceptibility
- Using STIR sequences instead of fat-saturation techniques that may have major sensitivity to inhomogeneity.





8. Slice-overlap artifact

- Also known as cross-talk artifact
- The loss of signal seen in an image from a multi-angle, multi-slice acquisition, as is obtained commonly in the lumbar spine.
- If the slices obtained at different disk spaces are not parallel, they may overlap.
- If two levels are acquired at the same time, e.g. L4-L5 and L5-S1, the level acquired second will include spins that have already been saturated.
- This causes a horizontal band of signal loss crossing the image, usually most pronounced posteriorly.
- The dark horizontal band at the bottom of the following axial image through the lumbar spine demonstrates this artifact.



9. Magic angle artifact

- Occurs in sequences with a short TE (less than 32 ms) - T1 weighted, proton density weighted, and gradient echo sequences.
- It is confined to regions of tightly bound collagen at 54.74° from the main magnetic field (B_0), and appears hyperintense, thus potentially being mistaken for tendinopathy.

Normal

- In tightly-bound collagen, water molecules are restricted usually causing very short T2 times, accounting for the lack of signal.

Artifact

- When molecules lie at 54.74°, there is lengthening of T2 times with corresponding increase in signal. Thus in short TE sequences, the T2 signal does not decay significantly before the scanner picks up the signal. On the other hand, in long TE sequences (like T2 weighted sequences), by the time the scanner picks up the signal, the T2 signal has already decayed.
- The reason for this change is due to quantum mechanics: in the set of equations that describe the interaction of spins (their Hamiltonian), there are several terms that are orientation-dependent. Normally, these orientations are averaged over as protons tumble around thermally, but in sites with long-range order, these terms can be important. In the case of structured collagen, lots of water binds to the outside of the protein, and therefore exhibits an orientation-dependent effect.

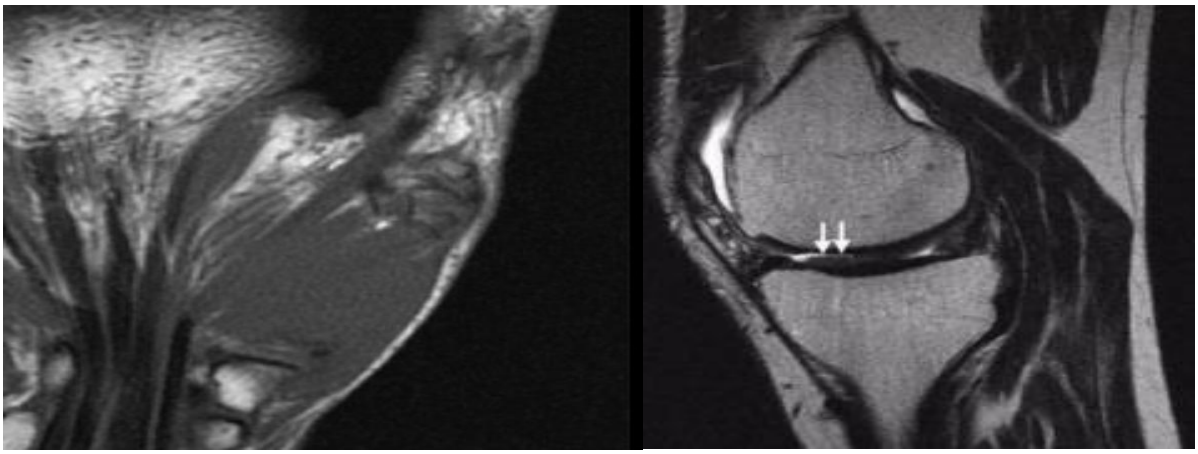
Typical sites include:

- proximal part of the posterior cruciate ligament (PCL)
- infrapatellar tendon at the tibial insertion
- peroneal tendons as they hook around the lateral malleolus
- cartilage, e.g. femoral condyles
- supraspinatus tendon
- triangular fibrocartilage complex (if the patient is imaged with the arm elevated)

It appears that the effects are reduced in a 3 T MRI system compared to a 1.5 T system.
Other non-pathological causes of high signal within tendons include near tendon insertions and/or where the tendon normally fans out or merges with other tendons.

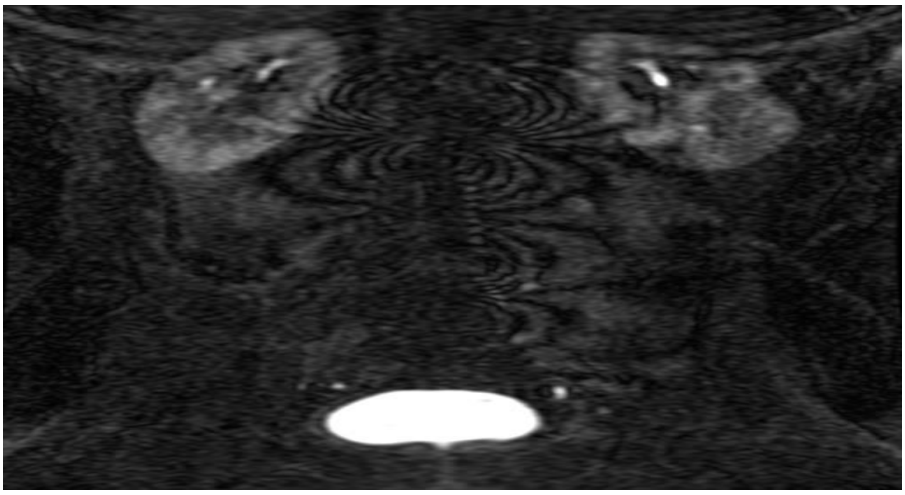
Solution:

- It only occurs in short TE sequences (e.g. T1, PD, GRE). Sequences with a longer TE (e.g. T2) can be used to avoid this artifact.



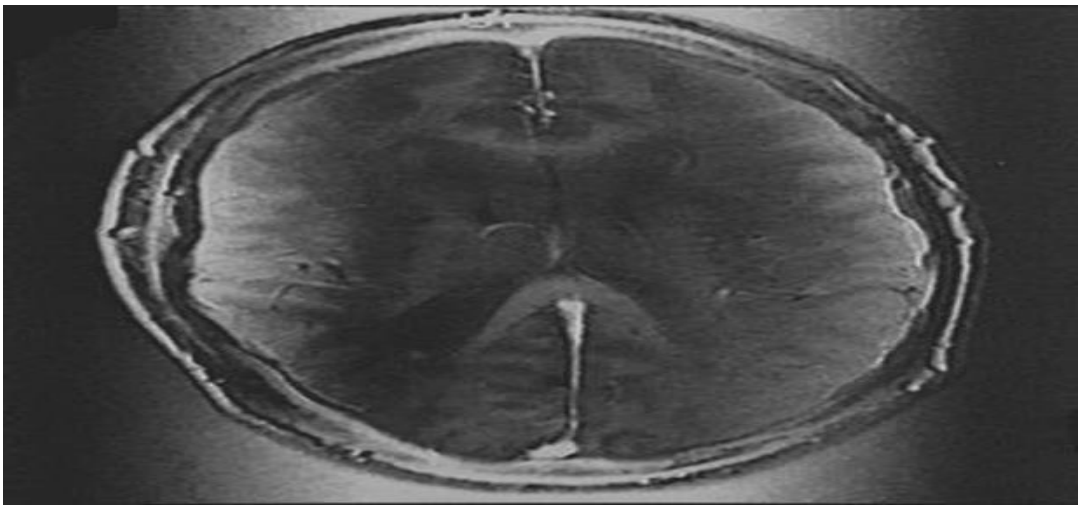
10. **Moiré fringes**

- Most commonly seen when acquiring gradient echo images using the body coil.
- Because of the lack of perfect homogeneity of the main magnetic field from one side of the body to the other, aliasing of one side of the body to the other results in the superimposition of signals of different phases that alternatively add and cancel.
- This causes the banding appearance similar to the effect of looking through two screen windows or through the railings of bridge from distance.
- Shimming will help to reduce this artifact by making the magnetic field more homogeneous.



11. RF overflow artifact

- **It** causes a nonuniform, washed-out appearance to an image.
- This artifact occurs when the signal received by the scanner from the patient is too intense to be accurately digitized by the analog-to-digital converter.
- Autoprescanning usually adjusts the receiver gain to prevent this from occurring but if the artifact still occurs, the receiver gain can be decreased manually .



12. Magnetic susceptibility artifacts

- They are especially encountered while imaging near metallic orthopedic hardware or dental work, and result from local magnetic field inhomogeneities introduced by the metallic object into the otherwise homogeneous external magnetic field.
- A common susceptibility-related artifact, deliberately sought to make small lesions more conspicuous, is the blooming artifact.

Types of magnetic susceptibility

A) Diamagnetic

- Water is considered (weakly) diamagnetic.

B)Paramagnetic

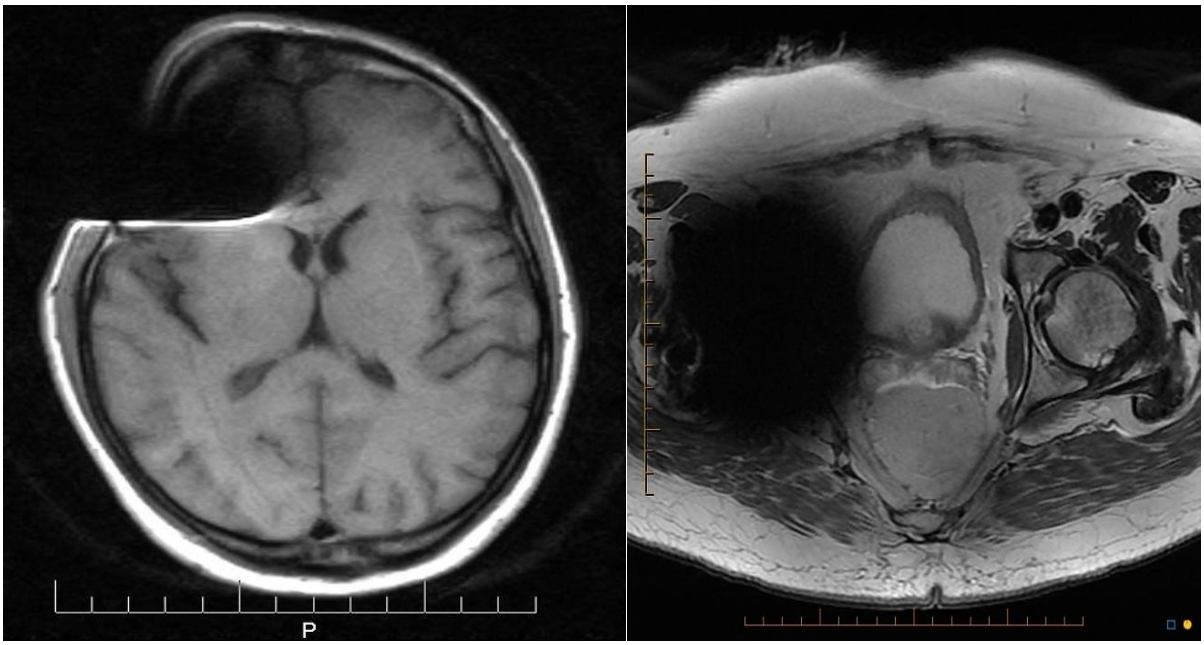
- Paramagnetic materials, which have unpaired electrons, concentrate local magnetic forces and thus increase the local magnetic field, i.e. have increased magnetic susceptibility.

C)Superparamagnetic

- Superparamagnetic materials contain particles with a much stronger magnetic susceptibility than that of paramagnetic materials, e.g. SPIO (superparamagnetic iron oxide) has been used in liver imaging.

D)Ferromagnetic

- Ferromagnetic materials contain large solid or crystalline aggregates of molecules with unpaired electrons and exhibit “magnetic memory”, by which a lingering magnetic field is created after their exposure to an external magnetic field. Examples of ferromagnetic metals include iron, nickel, and cobalt, all of which distort magnetic fields, thereby causing severe artifacts on MR images.

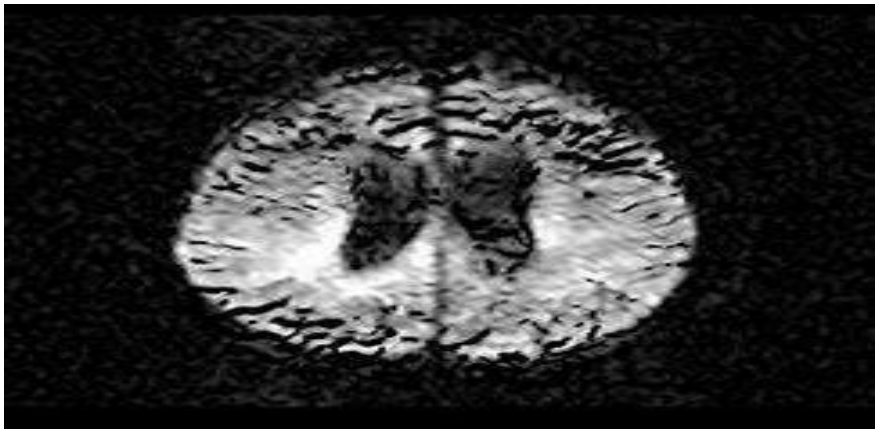


13. Eddy current artifact:

- Varying magnetic field induces electric current which distort gradient waveforms.
- When diffusion gradient applied, changes in magnetic field creates electric current.
- Such current creates smaller magnetic field.
- Modern gradient coil equipped with active shielding to avoid these effects of electric conduction.

Solution:

- Sheilding gradients.
- Distorted gradient waveform is used.



14. Herringbone artifact

- Also known as spike artifact, crisscross artifact, or corduroy artifact.
- It is an MRI artifact related to one or few aberrant data point(s) in k-space.
- In image space, the regularly spaced stripes resemble the appearance of a fabric with a herringbone pattern.
- The artifact covers the entire image in a single slice or multiple slices.

Causes

- Electromagnetic spikes by gradient coils
- Fluctuating power supply
- RF pulse discrepancies

Compiled by: Dr Rashitha Raj, under the guidance of Dr Pravin G U Principal,Prof.RadioDiagnosis .
Sri Chamundeshwari Medical college Hospital & Research Institute,Channapatna,Karnataka.
REF : Christensen's Physics, Radiopedia.