MRI ARTIFACTS

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Strong magnetic fields and radio waves are implemented in magnetic resonance imaging (MRI), which produces highly accurate images of the internal organs of the body. artifacts are visual abnormalities that appear in an MRI image that do not match the actual scanned object. (MR) imaging artifacts are the result of the complex interplay of modern imaging machine subsystems, including primary magnets, gradient coils, radio frequency transmitters and receivers (RF) and the reconstruction algorithm is used.

All MRI images contain artifacts. Some artifacts degrade image quality and can mask or even simulate pathology. Therefore, it is crucial to comprehend both their root causes and their remedies.

Several things can result in artifacts., such as image processing, patient movement, tissue heterogeneity, magnetic field heterogeneity, radio frequency interference, error gradient and flow effect. Foreign bodies, metallic surgical implants, voluntary and physiological motions are a few that are connected to the patient. Gibbs spoofing along with authoring can be brought on by finite sampling, K-space encoding, and the Fourier transform. Artifacts like black border, moiré, and phase coding can be attributed to pulse sequence features. Midpoint and RF spillover can be a consequence of problems with the equipment.

There are several MRI artifacts, and they shed light on the physics underlying each sequence. Some artefacts have an impact on the accuracy of the MRI scan, while others do not have an impact on the accuracy of the medical evaluation but may be mistaken for pathology. The other antiques, which we deliberately created for flow demonstration, pathologic visualization, or lesion characterization, were all effective. Some artifacts cannot be changed and are only reduced, not eliminated. Others may be able to avoid it altogether.

The artifact's categorisation can provide insight into possible solutions. Three major categories can be used to categorise artifacts:

(a) artifacts associated with magnetic field imperfections, including static magnetic fields, radio frequency (RF) fields, and gradient fields;

(b) motion related artifacts; And

(c) Artifacts from the methods used to sample the MR signal.

It is useful to gradually go over the artifact's broad qualities whenever you come across a mysterious object in an attempt to determine its overarching category. These traits involve the following:

1. Sequence variety, such as volumetric collection, gradient, and rapidly rotating echo

2. Phase and frequency orientation

3. Signals in fat or liquid

4. the existence of anatomical structures beneath the ocular domain

5. A metallic foreign body is present

Having an extensive knowledge of the origins of artefacts aids in MRI imaging system functionality optimization. Some artifacts can degrade image quality and interfere with diagnosis, while others can mimic pathology and lead to false-positive or false-negative results. Therefore, it is important to recognize and minimize these phenomena using the appropriate settings, techniques, and image corrections.

Many different phenomena can occur on an MRI. The growing clinical use of very high-intensity, high-performance gradients, and multiple RF channels also calls for renewed attention to the biological and physical safety implications of magnetic resonance imaging. Radiologists should be aware of the potential physiological effects of prolonged exposure to magnetic fields, acoustic noise, and RF energy during MRI and should use all available methods. To avoid accidents and side effects. Imaging equipment should be checked and monitored regularly to ensure stability and stable operation. Newly installed or upgraded MR systems must be checked by a qualified physicist or engineer prior to use.

Many different artifacts occur in MRI, and MRI technicians and radiologists must know how to identify and avoid these phenomena in order to produce images. consistently high quality. To avoid confusion when writing reports, radiologists should be aware of these phenomena. In addition, MRI technicians must be able to identify spurious phenomena and understand their causes and solutions to produce consistently high-quality images.

For each artifact, there is a description of the phenomenon and its causes, as well as suggestions for how to minimize or avoid similar phenomena.

CLASSIFICATION OF ATRIFACTS

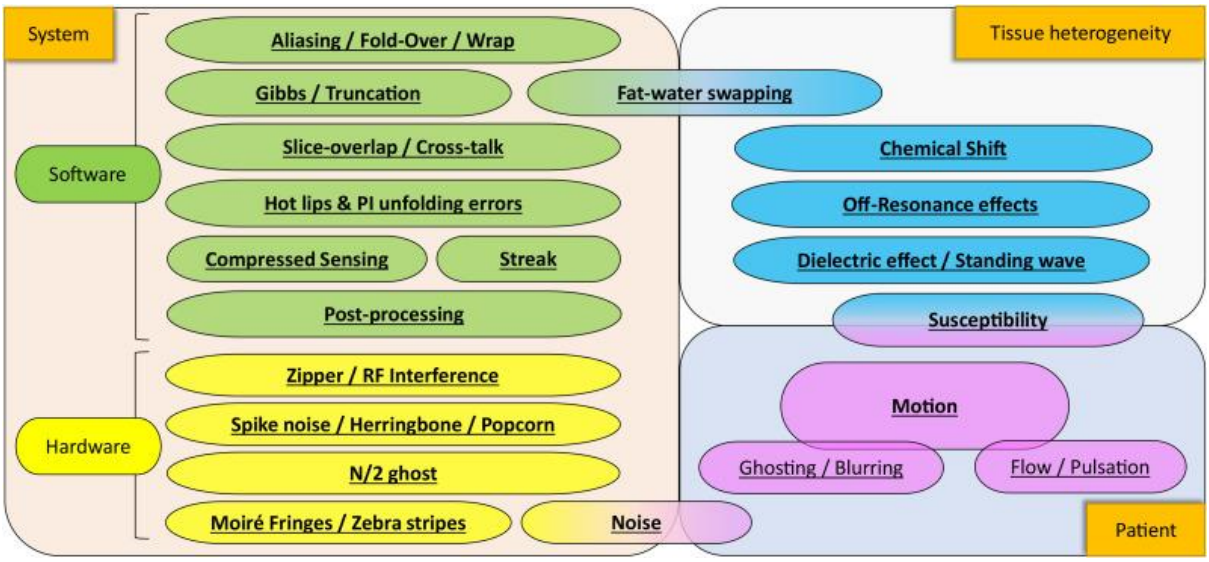

Figure 1 flow chart of MR Artifacts.

1. **MRI hardware & Room Shielding**

A. Zipper Artifact
B. Herringbone Artifact
C. Moiré Artifact
D. Central Point Artifact
E. RF Overflow Artifact
F. Inhomogeneity Artifact
G. Shading Artifact
H. Aliasing Artifact/ Wrap Around Artifact
I. Starry Sky Artifact

2. **MRI Software**

A. Slice – Overlap Artifact / Cross- talk Artifact
B. Cross Excitation Artifact

3. **Patient and Physiologic Motion**
    A. Phase – Encoded Motion Artifact
        - Ventricular CSF Pulsation Artifact
    B. Entry – Slice Phenomenon.

4. **Tissue Heterogeneity And Foreign Bodies.**
    A. Black Boundary Artifact
    B. Magic Angle Effect Artifact
    C. Magnetic Susceptibility Artifact
        - Blooming Artifact.
    D. Chemical shift Artifact
    E. Dielectric Effect Artifact.

5. **Fourier Transform And Nyquist Sampling Theorem.**
    A. Gibbs Artifact / Truncation Artifact
    B. Zero – Fill Artifact
    C. Aliasing / Wrap Around Artifact.

1. MRI HARDWARE AND ROOM SHIELDING

A. ZIPPER ARTIFACT

One or more bands of spurious electronic noise spread over the image. These findings may be a result of software or hardware glitches with the shield or the scanning device.

A common cause is spurious radio frequency signals that contaminate the received image data. In this case, the direction in which the artifact is seen depends on the direction of the encoded frequency and will appear perpendicular to the direction of the frequency encoding.

APPEARANCE -

A broad dashed line perpendicular to the frequency encoding direction that spans an image indicates the Zipper artefact.

CAUSE-

caused by external RF invading the area at a frequency that correlates with the expected frequency in the echo. by functioning the scanning device through leaving the magnetic room entrance open or via a passageway in the RF cage.

REMEDY -

All the time shut the magnetic room door while acquiring data. To find certain RF shield troubles and remedy them, consult a professional engineer.

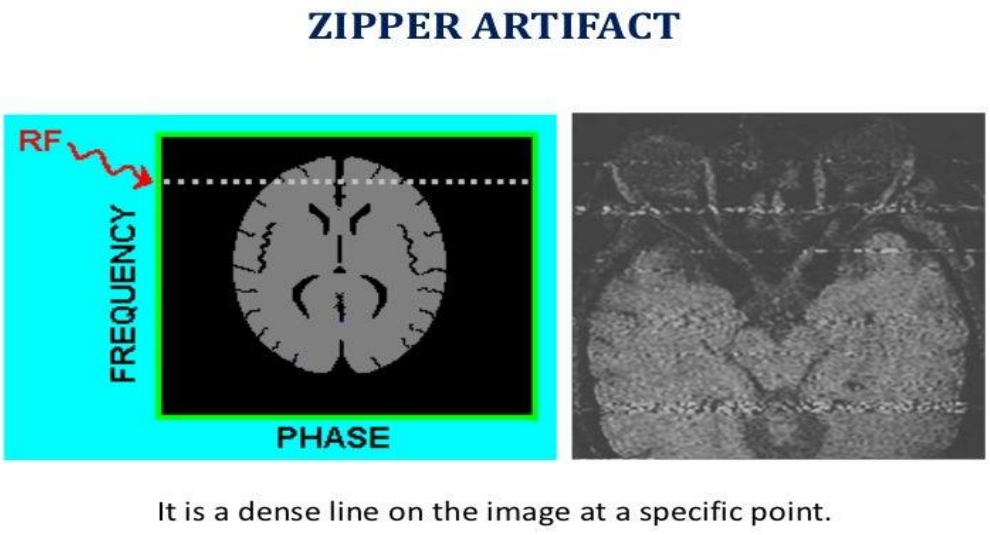

Figure 2 zipper Artifact.

B. HERRINGBONE ARTIFACT

A magnetic resonance image (MRI) artifact comprising one or more abnormal information points in K space is termed to as a herringbone artifact, spike artifact, cross artifact, or velvet artifact.

APPEARANCE-

- In the visual space, the evenly spaced stripes look like the exterior of a herringbone pattern fabric. Artifacts cover the entire image in one or more slices.

CAUSE-

- Poor pixels in K-space images, often due to hardware failure.
- This phenomenon is caused by electromagnetic pulses generated by diverging RF pulses from the power supply of the gradient coil.

REMEDY-

- Repeat analysis.
- If spurious phenomenon persists, repair of the scanner will be required.

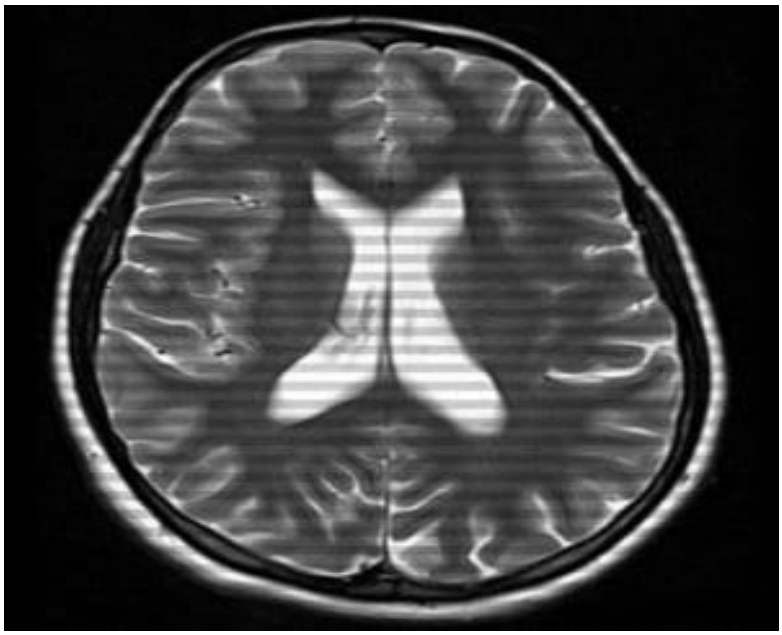

Figure 3 Herringbone Artifact

C. MOIRÉ FRINGES

This is due to noise patterns between the gradient of the MRI system and small samples of the object being imaged, such as a patient's body or medical devices.

APPEARANCE-

Rippled edges appear as fuzzy, wavy, or V-shaped patterns that overlap the MRI images. They can obscure the underlying anatomy, making images more difficult to interpret accurately.

CAUSE -

Moiré lacing occurs when there is an interaction between the normal mesh structure of the MRI gradient coil and the sample of the object being imaged, such as the fine texture of a garment or medical device. Colour-changing coils are used to spatially encode the MRI signal, and as they align or create interference patterns with signals on or within the patient, moiré contours can appear.

REMEDY -

- Reposition the patient in the MRI scanner to minimize interference between the gradient roller sample and the sample object.
- caused by patient clothing or accessories, you can ask the patient to remove or change them to reduce interference.
- Some MRI systems allow gradient settings to be adjusted. Small changes to gradient settings can help reduce noise that causes aliasing.

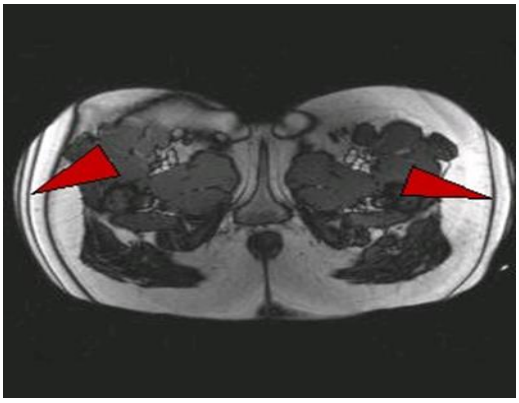

Figure 4. MOIRÉ FRINGES ARTIFACT

D. CENTRAL – POINT ARTIFACT

The enhanced signal in the central region of an image focuses on the midpoint artifact.

APPEARANCE - bright spot in the centre of the image.

CAUSE-

This is brought on via the receiver's steady DC voltage variance. This continual shift results in a vibrant point in the middle of the image after the Fourier transform.

A midway pseudo-point is displayed onto the cross-section in the middle of the axial MRI image of the brain.

REMEDY-

- the repetition of the sequence can remove artifacts.
- preserve the equipment area, where the receiving amplifier is located, and the imaging device at a consistent-temperatures.
- This application modifies the information in k-space and predicts the DC deviation.
- request a calibration from a service engineer .

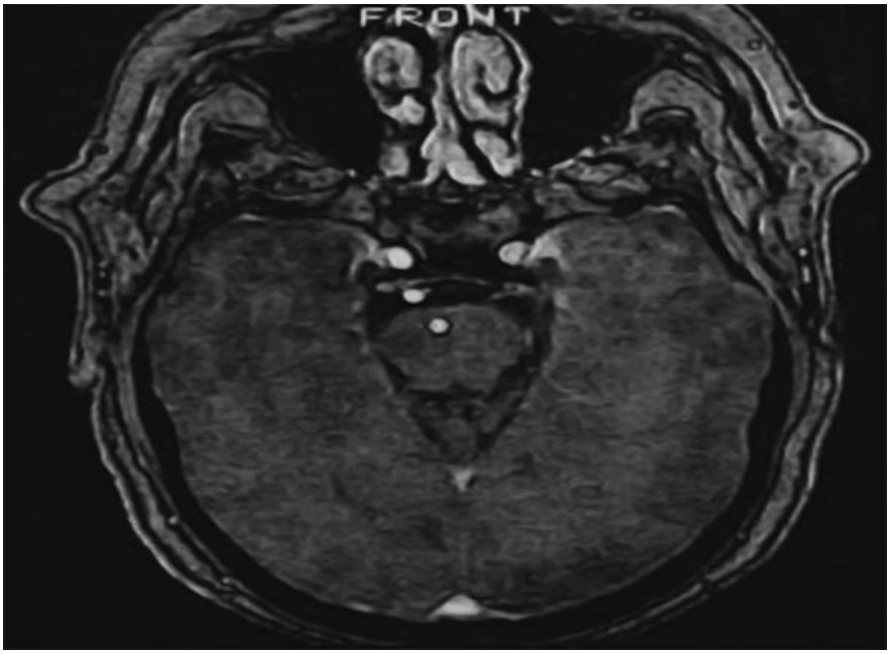

Figure 5 Central – Point Artifact.

E. RF OVERFLOW ARTIFACT

APPEARANCE – the image is uneven and blurry.

CAUSE - this occurs when the signal received by the scanner from the patient is too strong to be accurately digitized using an analog-to-digital converter.

REMEDY– Auto-pre-scan normally adjusts receiver gain to prevent this from happening, but if spurious still exists then receiver gain can be manually reduced. Further processing procedures are also accessible, although these may require hours.

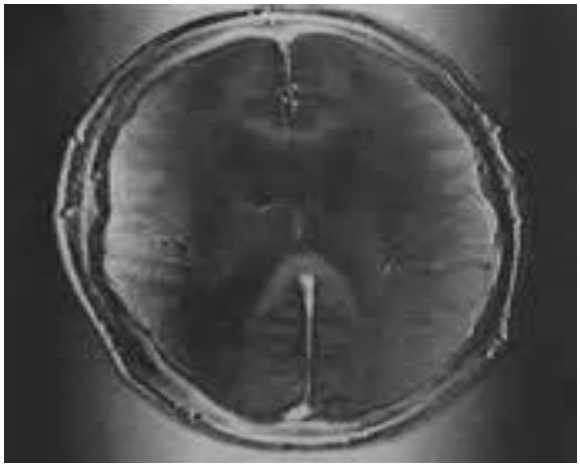

Figure 6 Rf overflow Artifact

F. INHOMOGENEITY ARTIFACT

APPEARANCE - increased or elevated signals in certain fat-suppressor sequences depend on the primary field (i.e., SPIR or SPAIR).

The main problem with this artifact is that it can simulate subcutaneous oedema or cellulitis. It is recommended to use strings that do not depend on the uniformity of the primary magnetic field

CAUSE - The phenomenon is caused by multiple factors, such as anatomical irregularities (e.g., shoulders, hips, ankles), presence of metallic objects, or primary field inhomogeneities.

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REMEDY -

• can be corrected using the timing coil during exam planning (at the FOV collection centre)

• examine the patient and the MRI frame before the examination begins, by removing metal or magnetically sensitive components

• using STIR sequencing instead of fat saturation techniques can be very sensitive to heterogeneity

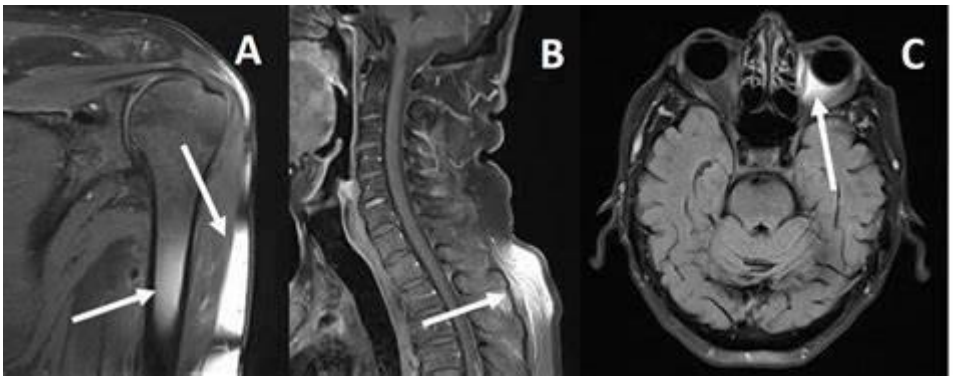

Figure 7 . INHOMOGENEITY ARTIFACT

G. SHADING ARTIFACT

APPEARANCE - results in a shadow in part of the image.

CAUSE - loss of signal strength in part of the image. This can be due to a number of factors, such as:

- Whenever the RF pulses are delivered at flip angles apart from 90 and 180 degrees, the nucleus is excited irregularly in the vicinity of the field.
- peculiar coil load and coil coupling on a specific location, such example when a tall patient touches the coil along one side.
- heterogeneity of the magnetic field.
- Overload in an analog-to-digital conversion.

REMEDY -

- Precise roll feed
- use a coil sized appropriately for the size of the patient and the part being examined
- minimise the chance that the patient's skin come into contact with the coil by placing an absorbent pad over them.
- wedges to lessen the variability of the magnetic field
- Select the required RF pulse amplitude applying the suitable sweep settings (with reduced strength to prevent analog-to-digital converter excess).

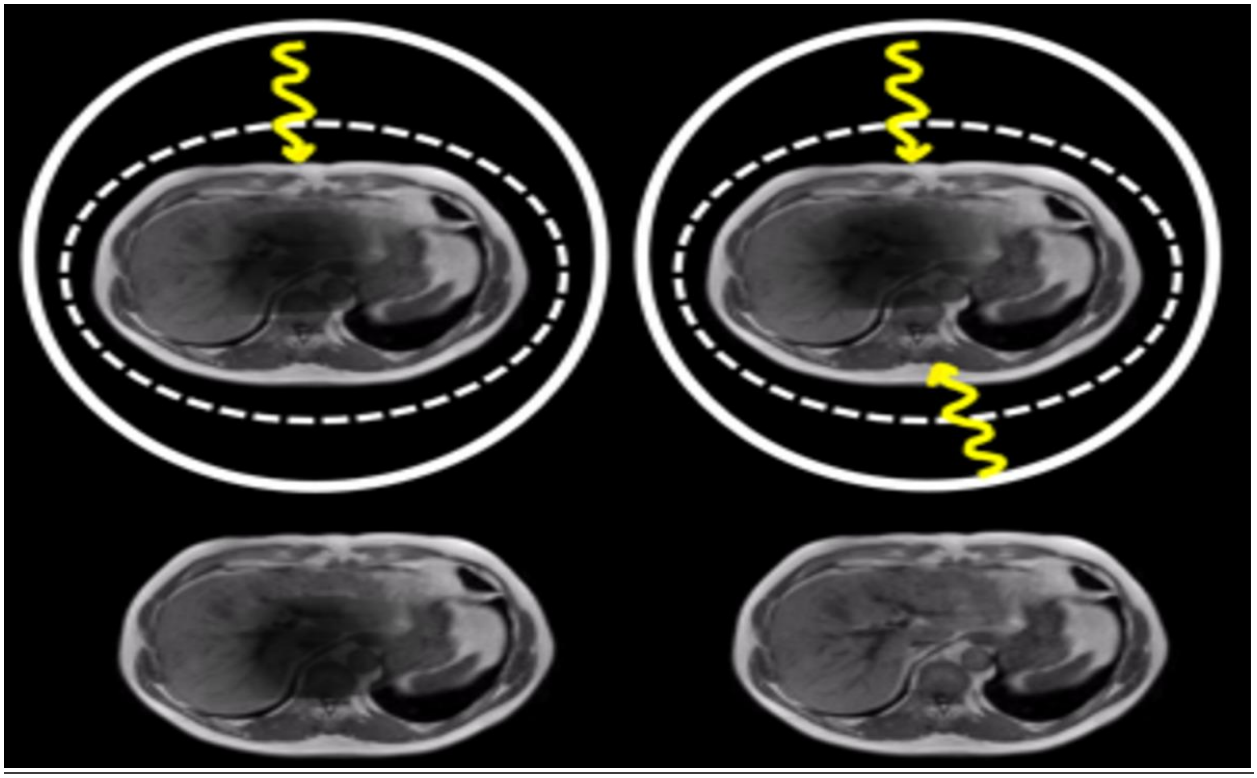

Figure 8 Shading Artifact

H. ALIASING ARTIFACT

APPEARANCE - A typical MRI phenomenon referred as an alias, additionally referred to as surround, happens when the field of view (FOV) is narrower than the area of the body being scanned. On the exact opposite sides of the image is displayed the region of the human anatomy that is beyond the field of view.

CAUSE - The gradient generally applies to the body's anatomy beyond the field of view, and if it is within the receiver coil's acquiring spectrum, it will emit a signal. The nuclei are localized on portions of the gradient far beyond the FOV, hence the signal from this anatomy has a frequency either higher or lower than the FOV. The frequency is incorrectly digitized and represented as a lower frequency if it is greater than the Nyquist frequency. frequency wrap, Frequency wrapping is a synonym for aliasing along the frequency encoding axis. Frequencies beyond the field of view will be higher than the Nyquist frequency and mapped to a lower frequency when the field of view is smaller than the structure of the organ in the picture frequency axis. This is known as high frequency aliasing.

Phase return refers to aliasing across an image's phase axis. This is the outcome of the information being gathered across the image's phase axis. Signals arriving inside of the FOV have a false frequency allocated to them because signals coming from beyond the FOV in phase direction are provided with a phase value.

REMEDY -

- enlarged field of view (FOV)
- Use pre-saturation band in out-of-field areas
- initiatives for eliminating aliasing.
- the transformation of the frequency and phase.
- For suppression of signals outside the area of interest, utilize surface coils.

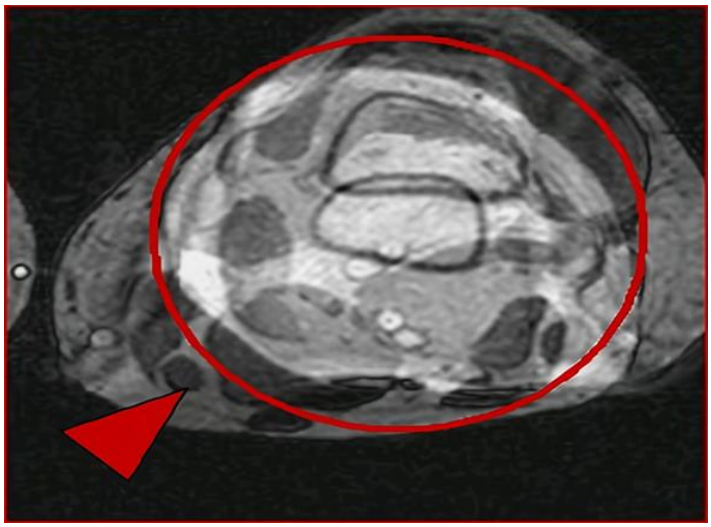

Figure 9 Aliasing Artifact

I. STARRY-SKY ARTIFACT

APPEARANCE – The centre part of the image, which is distant from the surface coils, tends to be impacted by starry sky distortions produced by parallel MRI imaging (such as SENSE). These distortions are rather prevalent and typically appear as a dispersed pattern of image noise. Surface granularity.

CAUSE –The geometric factor (g), a spatial variable, has a significant impact on the distribution of noise in parallel imaging. Additionally, it rises as the acceleration factor (R) rises. consequently, poor signal-to-noise ratio (SNR) regions are distributed disproportionately. The likelihood of this artefact increases in regions that are distant from the surface coil (for instance, subcutaneous tissue in major patient's).

REMEDY – SNR is increased when the R factor is decreased when imaging, however, the imaging duration is greatly extended. The sequence is merely primarily repeated to mitigate distortions.

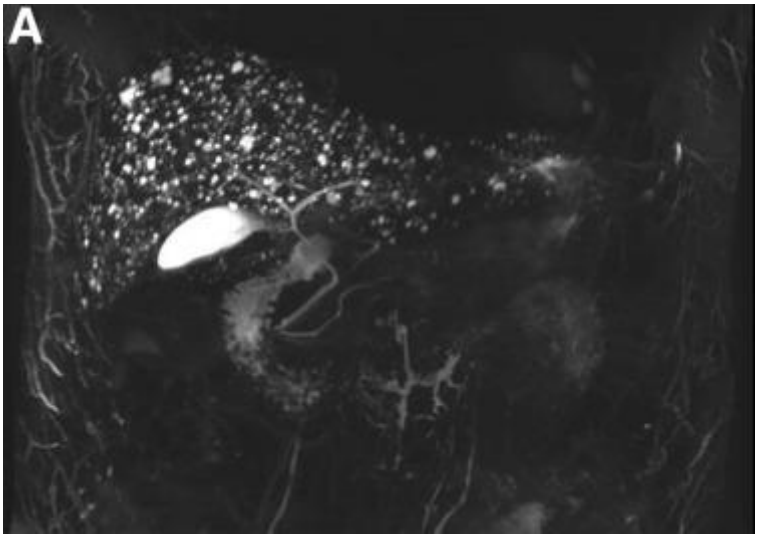

Figure 10 Stary- Sky Artifact.

2. MRI SOFTWARE

A. SLICE – OVERLAP ARTIFACT / CROSS – TALK ARTIFACT.

APPEARANCE – Slice overlap artifact, also known as crosstalk artifact, is a type of MRI artifact that is the loss of signal seen in images of multi-angle, multi-slice scans, typically seen in lumbar spine imaging. Contrast this with cross-excitation, which has an identical mechanism of action. There is not any visual aberration that causes cross-excitation.

CAUSE - Slices obtained on different disk regions may overlap if they are not parallel. If two levels (like L4-L5 and L5-S1) are taken at the same time, his second level taken will contain the already saturated spins. This causes horizontal bands of signal loss across the image, usually most noticeable towards the back. This phenomenon is highlighted by a gloomy horizontal strip at the bottom of the axial image throughout the lumbar region vertebra.

REMEDY- The simplest solution to avoid this artifact is to introduce a small gap, say 10-20°, between the slices so that the "tails" of the slice profiles do not overlap. Alternatively, you can use an interleaved acquisition where the odd slices are acquired first, then the even slices. This reduces the effects of saturation on neighbouring slices. The use of 3D imaging is preferred to visualize the entire volume without wasting time.

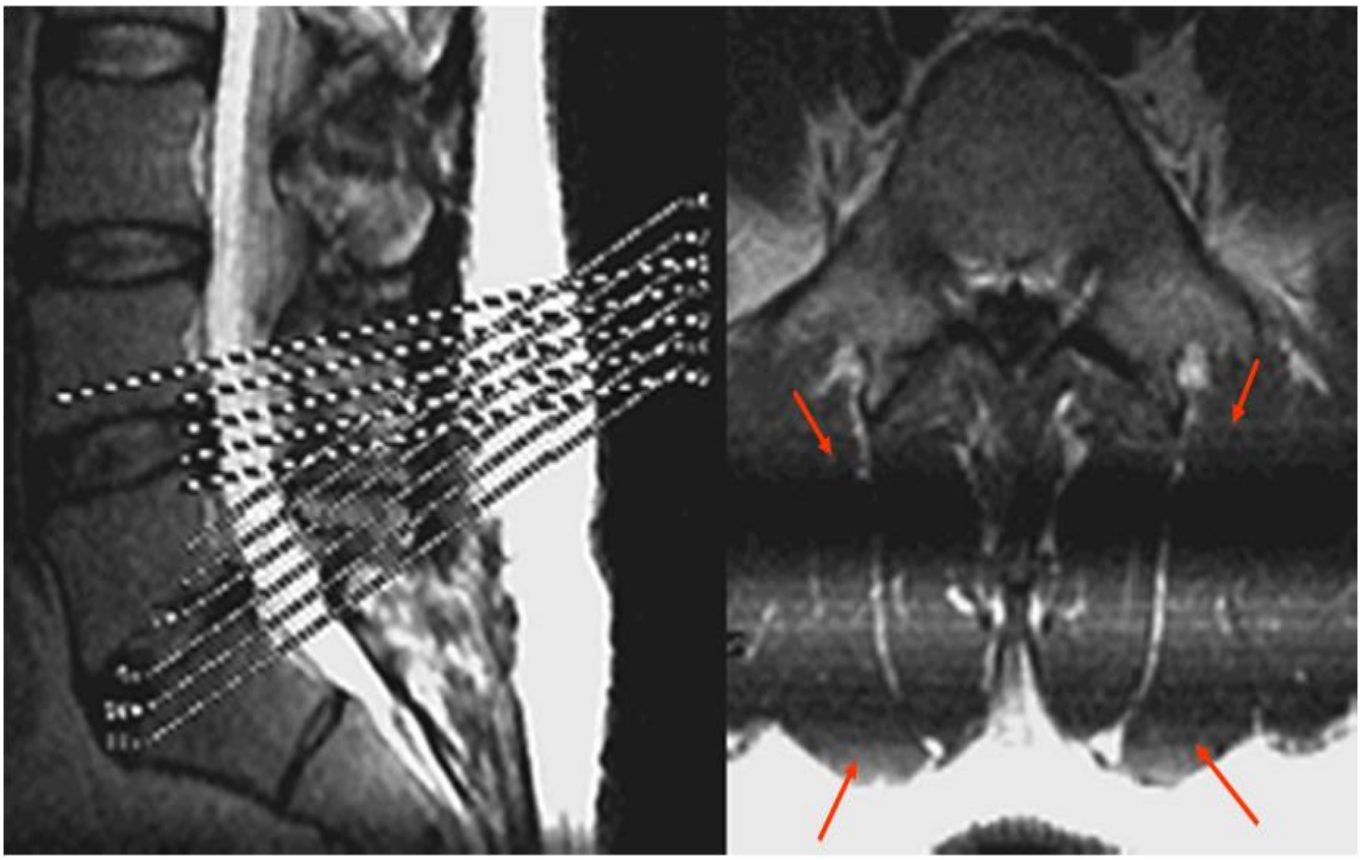

Figure 11 Slice Overlap Artifact

B. **CROSS – EXCITATION ARTIFACT.**

APPEARANCE –A specific kind of MRI distortion identified as cross-excitation implies to signal loss inside of a single slice as a consequence of pre-excitation by RF pulses delivered to nearby slices.

CAUSE -The RF pulse's frequency distribution is not completely full. This implies that whenever a slice gets selected, nearby slices are also somewhat aroused. This nearby slice will initially have been partially saturated, and the resultant signal will drop if it is imaged over an identical TR (i.e., multi-slice imaging) or shortly after (i.e., gapless imaging). In the inversion recovery (180°) sequence, this pattern of action is more obvious.

REMEDY -

• When imaging adjacent layers, maintain a minimum distance of 1/3 of the layer thickness.
• Sandwiching slices together

• when multidimensional imaging is needed, implementing three-dimensional visualization.
• Apply an improved pulse sequence that possesses a higher minimal TE and a delay constraint to cut down on the number of slices needed to achieve an appropriate TR.

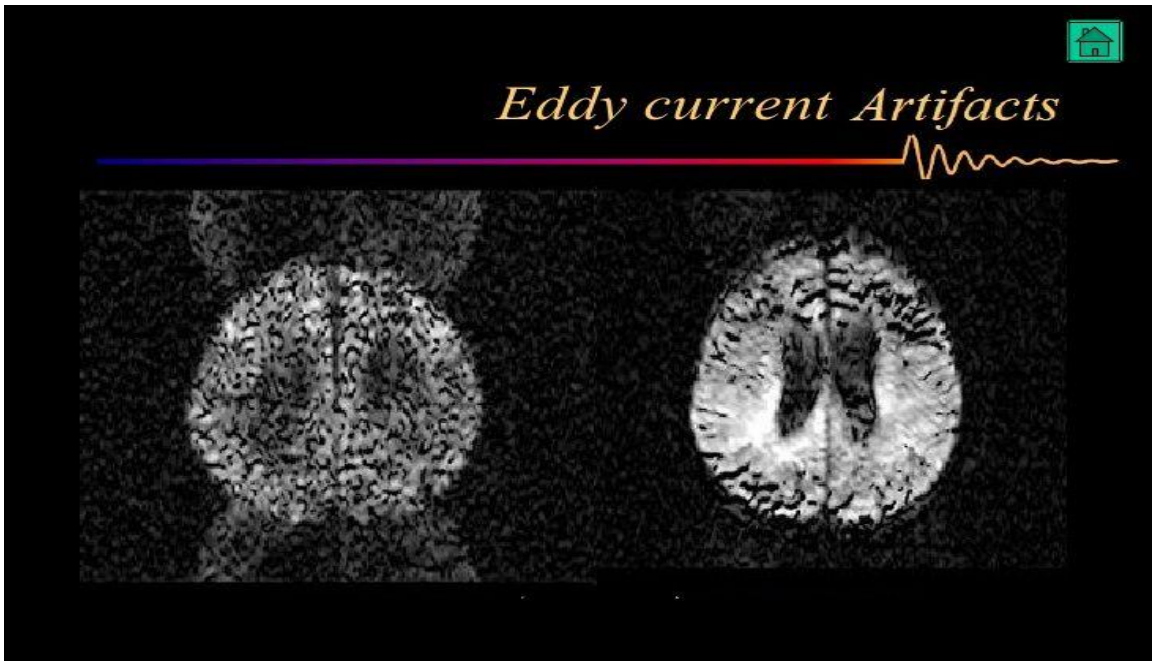

Figure 12 Cross - Excitation Artifacts

3. PATIENT AND PHYSIOLOGIC MOTION

A. PHASE-ENCODED MOTION ARTIFACT

APPEARANCE - results from tissue/fluid movement during scanning. In the phase-encoding direction, which is typically the shortest axis of the representation (i.e., from left to right in the axial or coronal brain and front-to-back in the axial abdomen), it manifests as a ghost image.

CAUSE – The patient's body motions, swallowing, breathing, peristalsis, and arterial pulse can all be used for identifying these irregularities. When projected onto anatomy, it can mimic pathology and should be recognized. Incidental motion, such as patient motion, produces smear in the phase direction. Periodic movements such as breathing and heart/vascular pulsation create discrete and distinct ghost images. The repetition time (TR) and frequency of movement determine how far apart these ghosts are from one another.
As contrast to truncation artefacts, which suddenly drop far from the border that creates them, motion artefacts cover the whole field of view (FOV), making them identifiable from Gibbs and truncation artifacts.

Here's how to identify phase artifacts:

1. Determine the distortions' alignment with the known shifting or flowing structures (horizontal or vertical, based on the phase-encoding configuration).
2. Adapt the ghost's structure to that of the streaming arterial (for example, an aortic ghost in a circular pseudo lesion).
3. Large window for observing repeated ghosts outside anatomical boundaries.
4. As they cover the full field of vision, they may be distinct from Gibbs and truncation artefacts, which suddenly drop away from the causal border.

REMEDY-

- Cardiac/respiratory gate
- Bands of spatial pre-saturation put across mobile tissues, especially as the cervical spine's anterior neck area.
- To lessen ghosting caused by vascular flow, place a spatial pre-saturation band beyond her field of view, preferably prior to the entry layer or after the exit layer.
- Veins along with arteries
- Scans typically limit the degree of movement in the abdomen.
- Switch between phase and frequency direction
- Increase the number of times the signal is averaged
- Decrease scan time when movement is caused by patient movement.

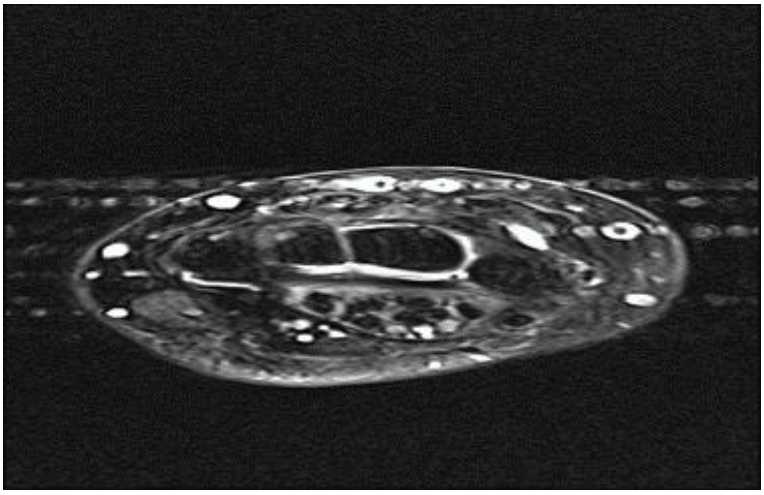

Figure 13 Phase – Encoded Artifact.

- **VENTRICULAR CSF - PULSATION ARTIFACT.**

Ventricular CSF beat artifacts are a common phenomenon seen in FLAIR (Fast Fluid Attenuated Inversion-Recovery) imaging of the brain.

APPEARANCE - This is an area of high signal content within the ventricle, usually on the left side, mimicking a lesion or thrombus.

CAUSE – This is caused by the movement of her CSF during the cardiac cycle, creating a phase difference between the CSF and resting tissue.

REMEDY - This artifact can be mitigated by using slow imaging techniques such as conventional His FLAIR sequences and spin-echo sequences.

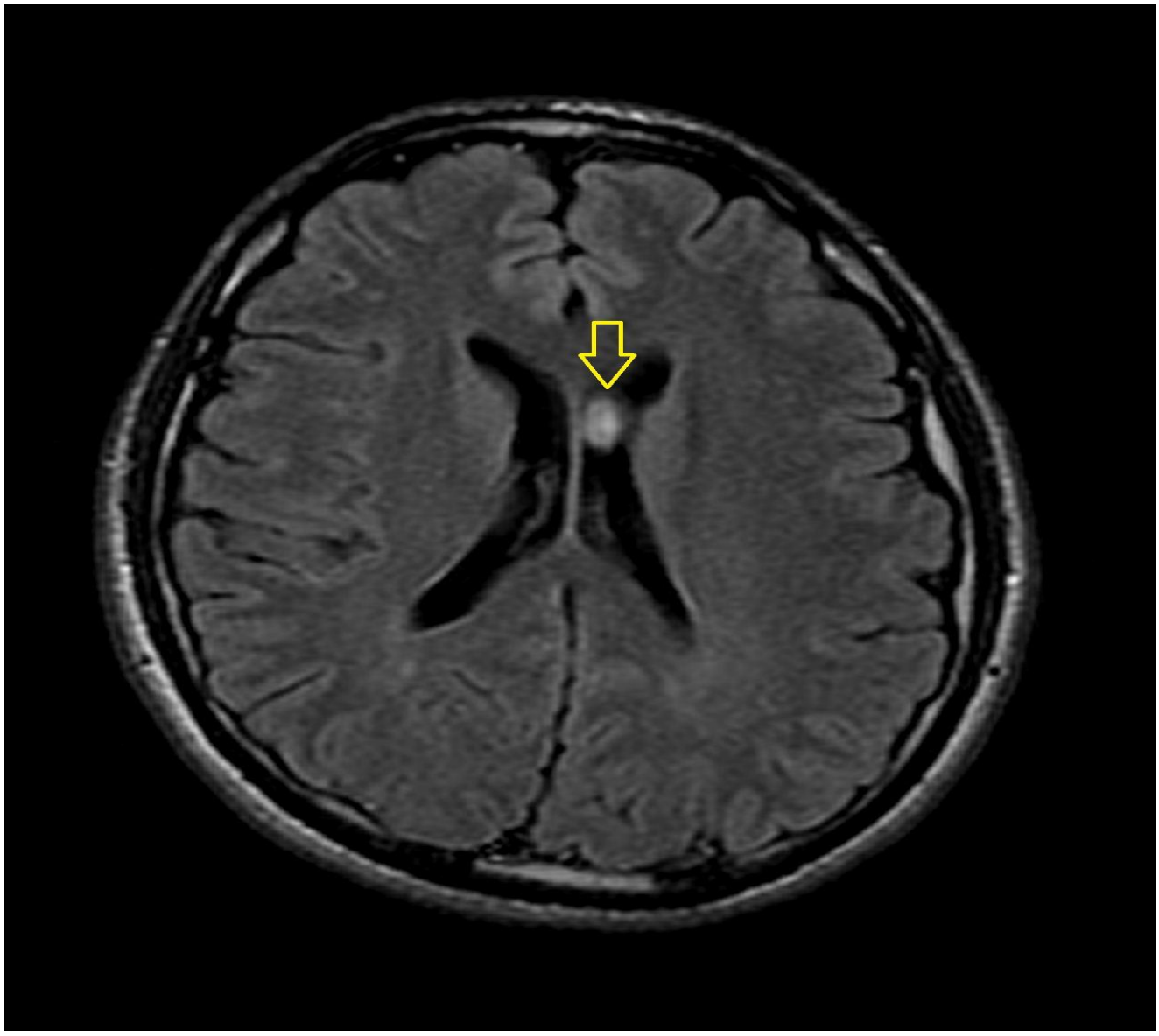

Figure 14 VENTRICULAR CSF PULSATION ARTIFACT

B. ENTRY SLICE PHENOMENON

Whenever unsaturated spinning in blood initially access a number of slices, it is known as the entrance slice phenomenon.

APPEARANCE - exhibiting a strong signal at the primary blood vessel (artery or vein) entry point in the incision plane. This is based on the phenomenon of high signal intensity associated with the flow of spins entering the imaging slice. Helps identify vascular and circulatory problems.

CAUSE - The signal is seen in multiple slices and gets weaker with distance. This artifact was mistaken for thrombosis, with dire consequences. Entry sliced artifacts and obstacles can be distinguished using distinctive locations and, if essential, gradient echo flow methods.

REMEDY - You can use a spatial saturation band before the first slice and after the last slice to remove this artifact.

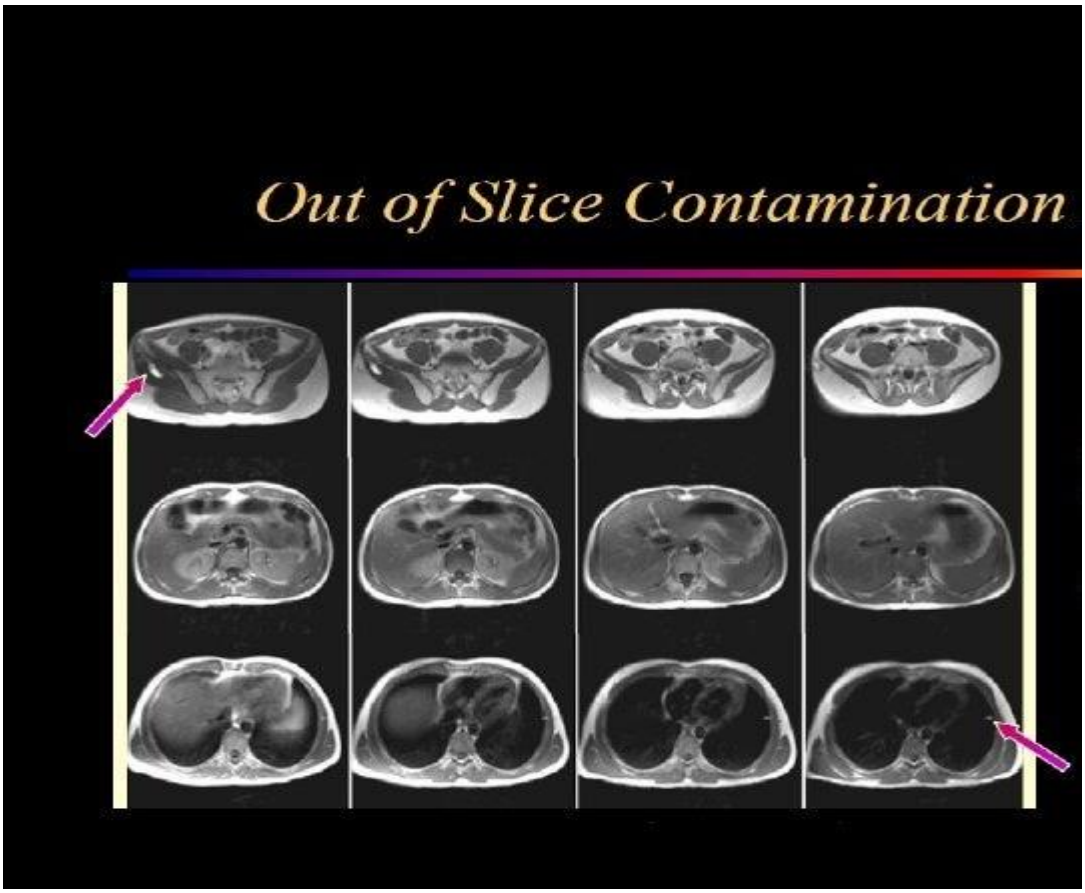

Figure 15 Entry - Slice Phenomenon Artifact

4. TISSUE HETEROGENEITY AND FOREIGN BODIES

A. BLACK – BOUNDARY ARTIFACT.

Artefact with a black border. often referred to as "type 2" chemical shift artefacts or ink artefacts.

APPEARANCE - This is the artificially formed black line that may be observed when fat and water adhere to, such as where muscle and fat interact. It sharply delineates the boundaries between muscle and fat, giving the image the appearance that someone has outlined these boundaries with ink. While this may be visually appealing, it does not represent anatomy.

CAUSE – occurs because to the choice of echo timings (TE) in a gradient echo (GE) sequence that cause rotations of fat and water (which is situated in the exact identical voxel of intersection) to cancel one another out of phase. At 1.5 T, a frequency difference of 3.5 ppm between water and saturated fat causes spin cancellation at multiples of 4.5 ms starting at approximately 2.3 ms. Since the spins are rephased by a 180-degree redirecting gradient in spin-echo (SE) sequences, this artefact doesn't exist in those sequences.

REMEDY-

- Select TEs around 4.5 ms, 9 ms, and 13.6 ms.
- Improved fat suppression
- Switch to SE sequences from GE.

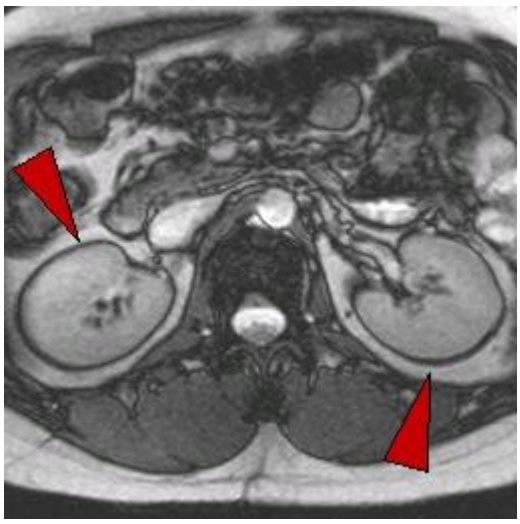

Figure 16 Black – Boundary Artifact.

B. MAGIC ANGLE EFFECT

APPEARANCE -

Magic angle artifacts produce abnormally high signal intensities in tissues containing collagen (such as tendons). This can be seen in the patellar tendon in Figure 17 and mimics the pathology.

CAUSE-

Fibrous tissue has unique physical characteristics which collaborate with static magnetic fields to produce this artefact. Dipolar interactions among water molecules and arranged fibrous collagen (such as tendons, ligaments, nerves, and menisci) lead to decrease in the T2 relaxation period. Based to the Fiber's angle with reference to the field axis B0, these interaction' strength fluctuate. The angles 0° and 90° are maximal and 55° are minimal.

The average weak signal in tendons, ligaments, and other connective tissue is caused by the underneath short T2 relaxation durations of these tissues, which are linked to dipolar interaction. However, when these fibrillar structures are at a 55° angle to B0, the T2 relaxation periods are more prolonged and maximum, resulting in a hypersignal of fluctuated strength.

REMEDY-

With PD, the degree of jitter triggered by the magic angle shifts.

It is maximum for relatively short TEs (around T2) and decreases with longer TEs. Angle dependent, the relative hypersignal change rises progressively between 0° and 55°. The T1 relaxation period is not significantly influenced by the magic angle. The T1 weighting sequence is therefore minimally influenced.

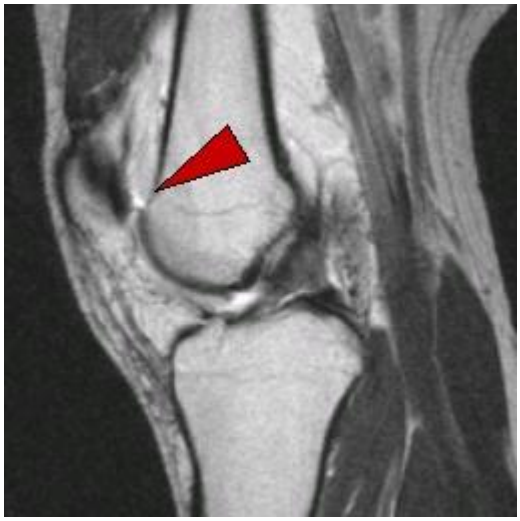

Figure 17 Magic – Angle Effect Artifact

C. **MAGNETIC SUSCEPTIBILITY ARTIFACT**

APPEARANCE - This artifact causes image distortion and large signal gaps.

CAUSE-

When tissue negotiates with an external magnetic field, it becomes intrinsically magnetized, which is referred to as magnetic susceptibility. The magnetic field is locally distorted when two tissues with varying magnetic susceptibilities are positioned close together. These naturally existing interactions can be found among trabecular bone and tissue as well as between air and tissue.

The T2* static magnetic field inhomogeneities induce close by spins to dephasing and fluctuate in frequency. As consequently, the MR images reveal artefacts, predominantly decreased signal strength but also the image distorting.

Metals, regardless of if considered ferromagnetic, can drastically change the magnetic field and induce susceptibility artefacts. The metallic material and the pulse sequence (spin echo, gradient echo) evaluate the signal degradation range. This signal loss comprises a variety of reasons:

- Localized inhomogeneities of the magnetic field (T2*) that enhance transverse relaxation and signal deterioration

- Apparently, a precession frequency shift as a consequence of the magnetic field distortion.

whenever a slice selection is made, however no spin excitation or signal is perceived.

As signals are acquired and readout gradients are applied, spatial orientation changes, resulting in signal loss and image distortion.

REMEDY-

• In contrast to gradient echo sequences, spin echo sequences are less prone to susceptibility artefacts. In SE, a 180° refocusing pulse corrects the T2* effect-related susceptibility-induced spin dephasing.

• The susceptibility artefacts are modified but not entirely eliminated by switching the direction of frequency and phase encoding.

• Short TE minimises signal degradation and dephasing time.

• Strong slope and wide receiver bandwidth both lower the minimum TE.

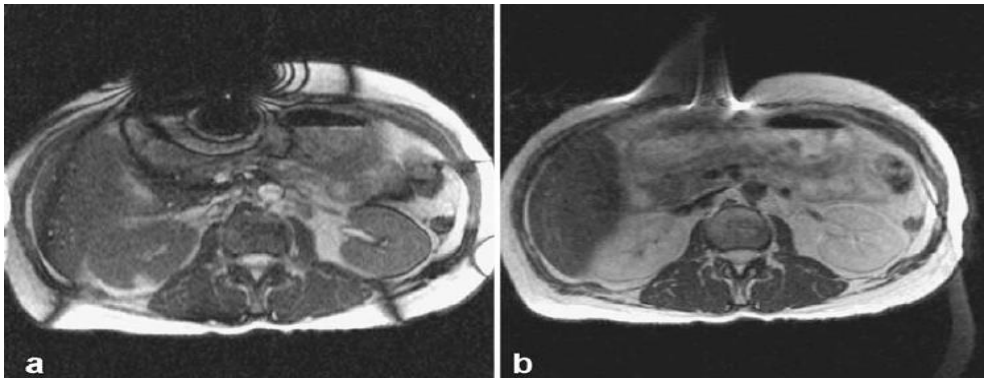

Figure 18 Magnetic Susceptibility Artifact.

o **BLOOMING ARTIFACT**

When paramagnetic materials are present in MRI sequences and have an impact on the surrounding magnetic environment, blooming artifacts—a kind of magnetic susceptibility artifact—appear. Likewise, to the way the T1-shortening effect of inadequate amounts of gadolinium is applied to determine improved contrast, it can be employed in particular to enhance the detection of some miniature lesions.

Susceptibility-weighted imaging (SWI) is among the most potent and popular sequences to optimise blooming artefacts with excellent results. When a specialized susceptibility-weighted sequence fails to exist, gradient echo and low B-value diffusion-weighted imaging could potentially be advantageous.

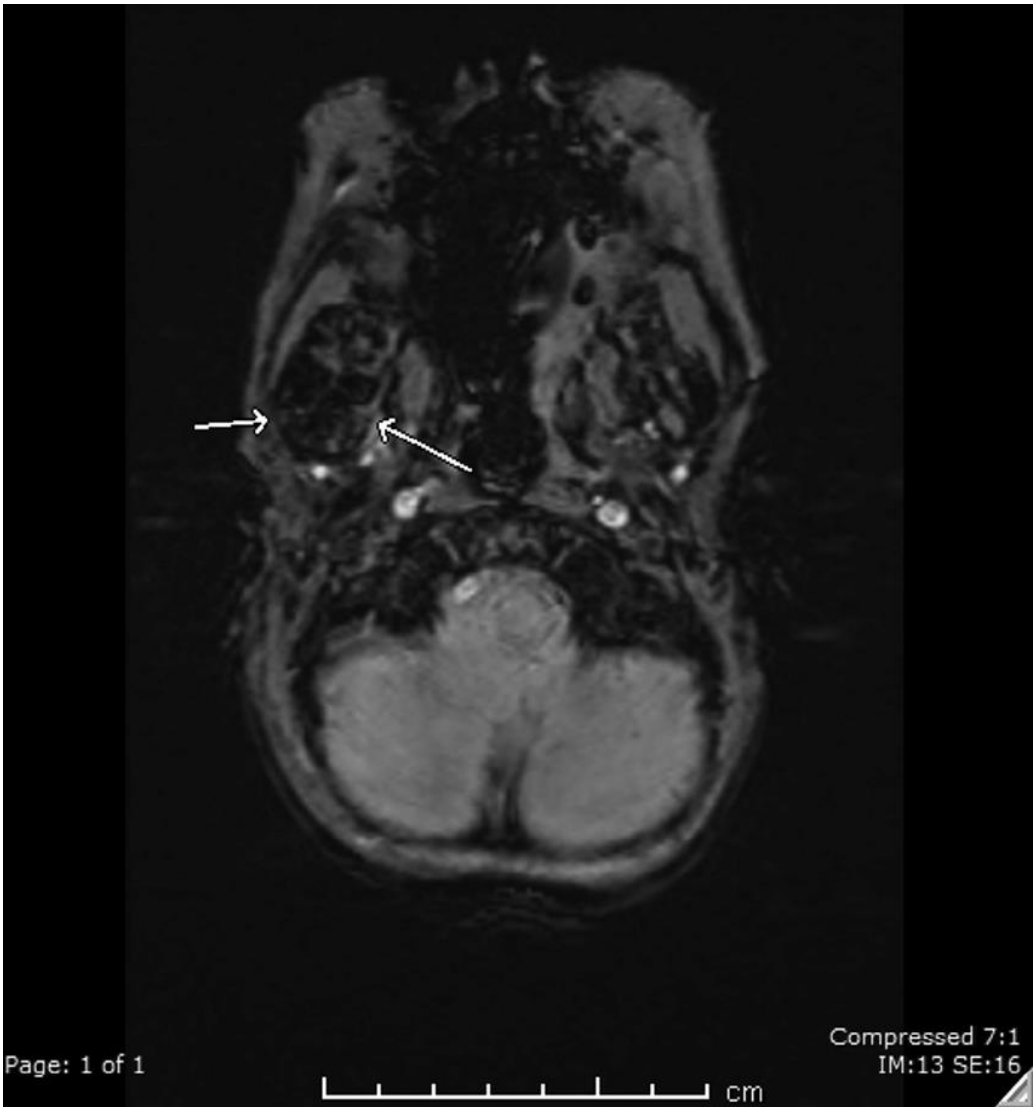

Figure 19 Blooming Artifact.

D. **CHEMICAL SHIFT ARTIFACT**

APPEARANCE - chemical shift artifacts displace the fat signal in the image. Dropouts and crosstalk (high signal) can also occur in areas where fat and water meet. The overall look gives a relief effect where the anatomy appears to be 'lighted' from one direction and 'shadowed' in the other. For this reason, this artifact is often called a bas-relief artifact.

CAUSE-The proton's chemical environment can induce a shift in the precession frequency due to the magnetic shielding by the electron shell. This resonance frequency shift exists between fat and water protons. This is approximately 3.5 ppm, corresponding to a difference of approximately 225 Hz at 1.5 T.

There are two types of chemical shift artifacts.

•Type 1is found in the frequency encoding direction and affects only field strengths above1 T.
• Type 2 can be detected at any field strength, but requires a GE sequence with a specific TE.
• Both of these spin echo (SE) and gradient echo (GE) sequences in MRI may exhibit a chemical shift misalignment either mismatch (Type 1 the chemical shifting artefact). Discrepancies occur in the direction of frequency encoding and appear as a bright band on one side of the fat-soft tissue interface and a dark band on the other side.
• In the presence of inconsistencies, GE sequence may also exhibit the black border or ink artefact (a type 2 chemical shift artefact), which is a sort of chemical shift artefact. At the fat-water interaction, this artefact produces black lines to run in every dimension. Because of a chemical shift or frequency variance, the fat and water spins in pixels with about equal quantities of fat and water are 180° out of phase at a given echo time, eliminating the signal.

REMEDY- Chemical shift artifacts are mitigated by fat suppression techniques (saturation, inversion recovery). This reduces the signal from fat and minimizes chemical shift artifacts.
Flipping the direction of frequency and phase encoding flips it in the other direction without removing chemical shift artifacts. This exchange also modifies other artifacts (wraparound, motion artifacts) and sequence parameters.
Another method is to use a larger receiver bandwidth. The higher the receiver bandwidth, the higher the bandwidth per pixel and the less visible chemical shift artifacts. The drawback is that the signal-to-noise ratio is reduced.

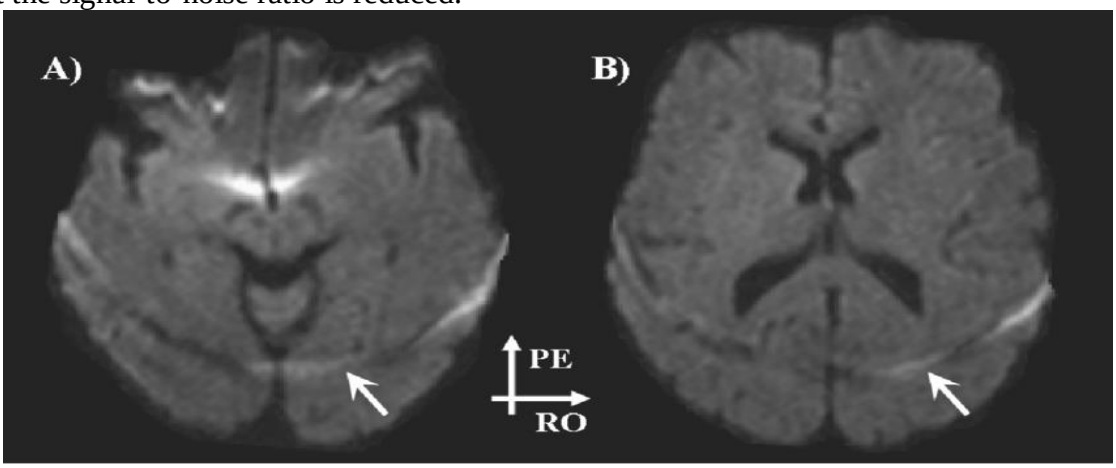

Figure 20 Chemical – Shift Artifact.

E. DIELECTRIC – EFFECT ARTIFACT.

APPEARANCE - At very high fields (above 3T), abnormally bright and dark regions are often observed due to inhomogeneities in the B1 field. However, the nature of these artifacts is not entirely clear.

CAUSE – The extent to which significant dielectric resonances cause these bright and dark regions is still a matter of debate. The relatively high electrical conductivity of tissue gives rise to the term "skin depth" used to dampen standing wave phenomena. Central brightening has been demonstrated in a high-conductivity phantom where dielectric resonance should be minimized. In summary, dielectric effects and their associated artifacts become increasingly important as electric field strength increases, but a simplified model of dielectrically induced standing waves may explain only a fraction of the phenomenon.

REMEDY - Use spiked water-based pads to reduce this artifact. They are easy to use and provide a cost-effective solution for improving B1 uniformity by reducing conductive and dielectric effects.

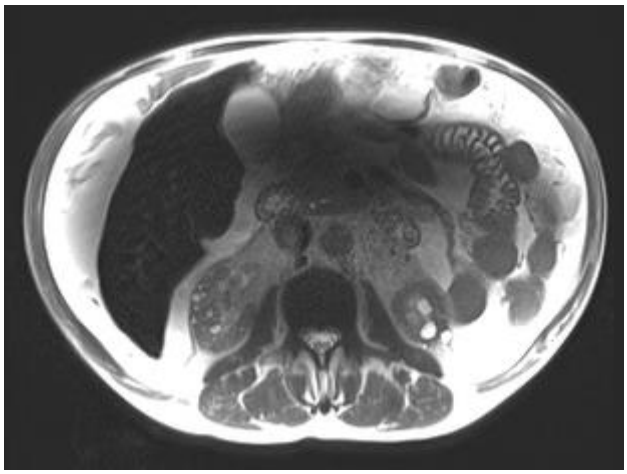

Figure 21 Dielectric – Effect Artifact.

5. FOURIER TRANSFORM & NYQUIST SAMPLING THEOREM.

A. GIBBS – ARTIFACT / TRUNCATION ARTIFACT.

APPEARANCE - Image reconstruction by Fourier transform from finitely sampled signals shows truncation or Gibbs artifacts as parallel lines adjacent to high-contrast interfaces.

CAUSE - Under-sampling the data (too fewer k-space lines are filled in) resulting in this artefact, which erroneously depicts the junction of the high- and low-frequency signals in the image. When the tissue continues to produce a strong signal at the point of data gathering or when echo peaks aren't concentrated in the middle of the sample frame, several things tend to happen. When employing TEs that are quite short, the latter is typical.

REMEDY -

Increasing the matrix size reduces truncation artifacts. However, this leads to a reduction in both voxel size and signal-to-noise ratio. Therefore, even if truncation artifacts are still present, they can be masked by image noise.

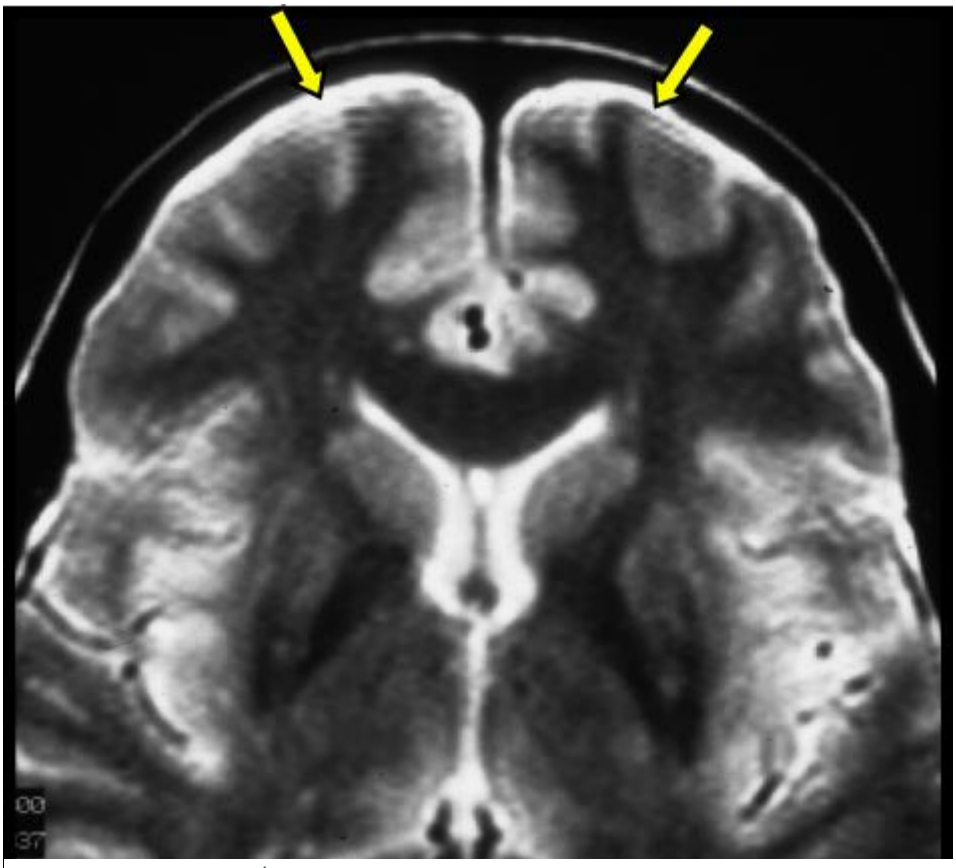

Figure 22 GIBBS ARTIFACT/TRUNCATION ARTIFACT

B. ZERO – FILL ARTIFACT.

One of the numerous MRI artefacts is zero-fill artefacts, arising from data being zeroed or being absent from the k-space array throughout imaging.

APPEARANCE - Sudden transitions from signal to no signal cause image artifacts, often showing diagonal stripes of alternating shadows and darks. K-space spikes, such as those caused by electrostatic sparks, are another artifact that causes distorted fringes.

CAUSE-

- Extraneous frequencies enter the room at frequencies corresponding to those expected in the echo.
- The scan room door is defective.
- Penetration into the HF cage.

REMEDY -

- Ensuring adequate shielding of the scan room and equipment.
- Check for loose connections or defective cables.
- Increase the number of averages or use interpolation techniques.

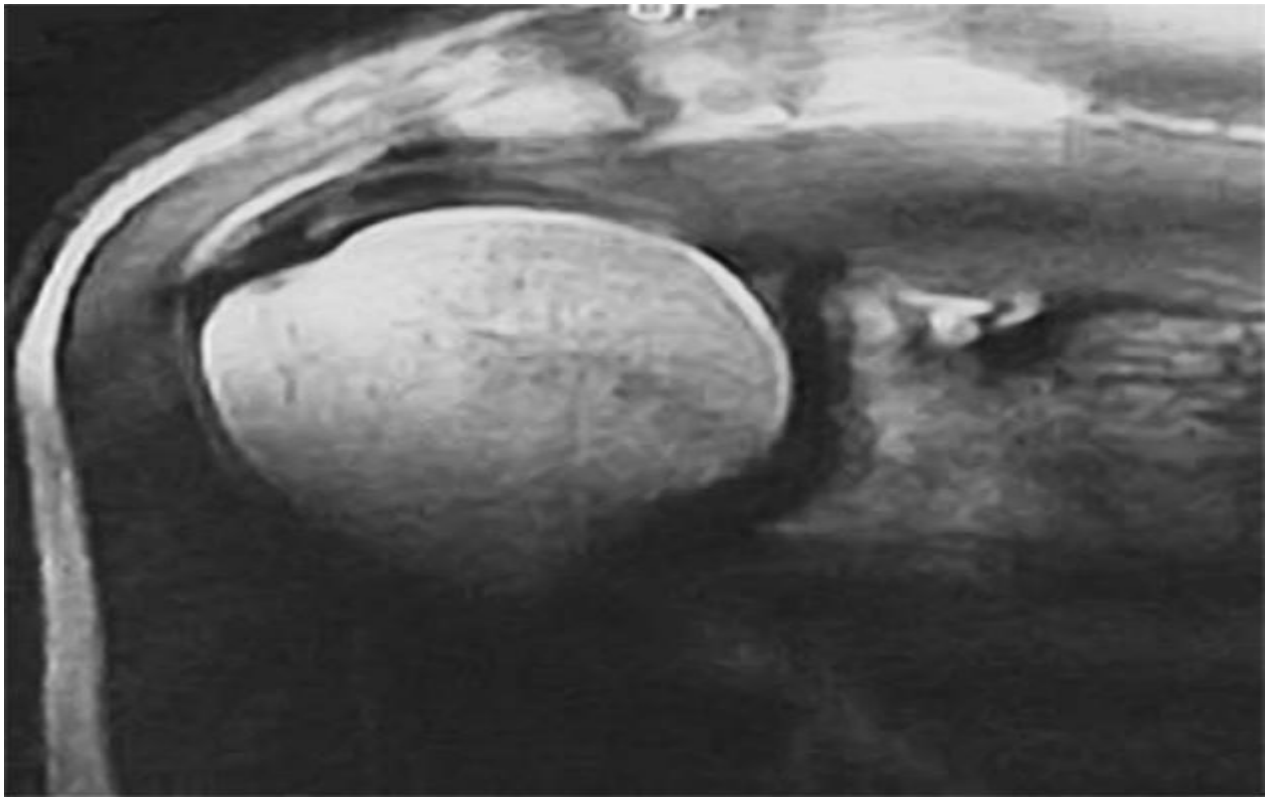

Figure 23 Zero - Fill Artifact

C. **ALIASING/WRAP AROUND ARTIFACT**.

APPEARANCE - Aliasing, or wraparound, is the overlap of signals outside the field of view on opposite sides of the image.

CAUSE - Indistinguishable from events within the FOV due to inadequate spatial encoding for objects beyond the FOV. This leads to a spatial discrepancy on the image's other side. Despite the aforementioned artefact can appear in both of the phase-encode and frequency-encode directions, it mainly impacts the phase-encode direction.

Phase values between -180° and +180° are acceptable. It is a location on a circle which corresponds to an angle. Phases of 180° and 220° equate to -180°, -160° (200° - 360°), and -140°, respectively.

In phase encoding, spins' phases alter in the slice plane's direction The initial coding phase allocates a shift in phase between -180° and +180° to encompass the entire field of view. The greater variations used in the following phase encoding steps—-360°/+360°, -540°/+540°, etc.—are generally multiples of -180°/+180. The phase encoding gradient is put into effect over the patient's body, therefore if the object extends outside the field of view, there will be a phase shift, but the value will be beyond the acceptable range.

REMEDY-

There are many ways to manage aliases. Changing the positions of frequency encoding and phase encoding to ensure the direction of phase encoding matches with the small diameter of the body portion being imaged is one of his techniques for addressing wraparound. The positive aspect corresponds to the alignment enables the utilization of rectangular arrays having identical spatial resolution while requiring lesser phase-encoding steps . It also affects other artefacts (such ghosting and chemical shift artefacts), which reduces the method's utility. There's no aliasing will happen if the FOV entirely encloses the body portion being examined in the phase encoding direction. However, the range of phase-encoding steps needs to be risen, which reduces the amount of time available for acquisition while maintaining the same spatial resolution.

Neither losing temporal or spatial resolution, the phase-less wrap approach eliminates aliasing, although at the value of signal-to-noise ratio. It includes:

- An increase of the FOV in the phase encode direction

- Increasing the phase encoding phases by two (while maintaining the identical spatial resolution).

- Eliminate the signal-to-noise ratio while maintaining the same scan duration by halving the amount of averages.

- Display images in a custom field of view.

Aliasing for frequency encoding

Wraparound can theoretically also occur in the frequency encoding direction. Due to poor sampling, high frequency signals can be misinterpreted as low frequency signals. The sampling rate of the MR signal should be a minimum of twice as high as the highest anticipated frequency in order to prevent frequency aliasing. The Nyquist frequency refers to this crucial sampling frequency.

Frequency aliasing is eliminated by advanced MR scanners using:

- data sampling excessively when digitizing MR signals.
- employ a bandpass filter in order to eliminate the highest frequencies.

There are no drawbacks to these techniques with regard to of image quality or processing speed.

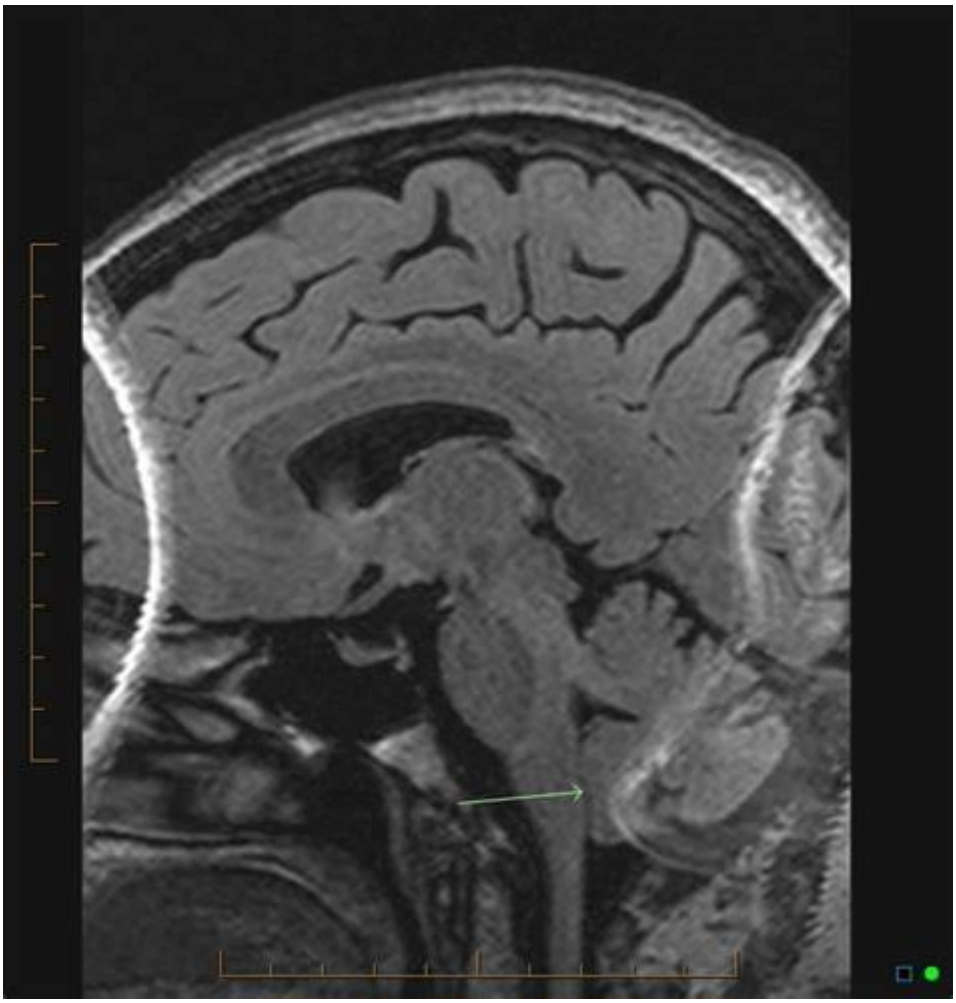

Figure 24 Aliasing/Wrap - around Artifact.

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