MRI ARTIFACTS

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Magnetic resonance imaging (MRI), is a scan which utilizes strong magnetic fields and radio waves for producing detailed images of the inside 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. So, it is very important to understand their causes and how to fix them.

Artifacts are caused by a variety of factors, such as image processing, patient movement, tissue heterogeneity, magnetic field heterogeneity, radio frequency interference, error gradient and flow effect. Some are related to the patient, such as voluntary and physiological movements, metal implants, or foreign bodies. Finite sampling, K-space encoding, and Fourier transform can cause Gibbs spoofing and authoring. Pulse sequence characteristics can cause black boundary, moiré, and phase coding artifacts. Hardware problems can cause midpoint and RF spillover.

MRI artifacts are abundant and provide insight into the physics behind each sequence. Some artifacts affect the quality of the MRI examination, while others do not affect the quality of the diagnosis but can be confused with pathology. The other artifacts were all beneficial and we intentionally created them for flow demonstration, pathologic visualization, or characterization of lesions. Some artifacts cannot be changed and are only reduced, not eliminated. Others may be able to avoid it altogether.

The classification of the artifact can give an idea of how to try to fix it. Artifacts can be divided into three main groups:

(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.

When you encounter an unknown artifact, it is helpful to systematically examine the general characteristics of the artifact to try to understand its general type. These features include: -

1. sequence type, e.g.- rapid rotation echo, gradient, volumetric collection

2. direction of phase and frequency

3. fat or liquid signal

4. the presence of anatomy outside the visual field

5. presence of metal foreign body

Understanding the sources of artifacts helps to optimize the performance of the MRI imaging system. 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

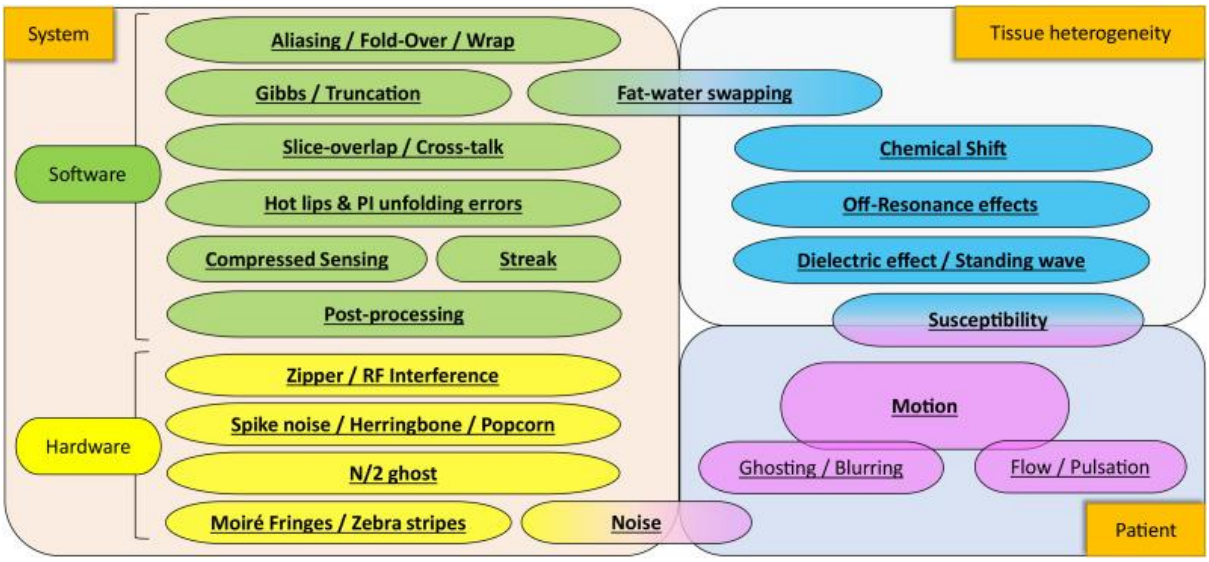

Figure 1 flow chart of MR Artifacts.

1. MRI hardware and room shielding

- Zipper artifact
- herringbone artifact
- Moiré fringes
- central point artifact
- RF overflow artifact
- inhomogeneity artifact
- shading artifact
- Aliasing artifact (also known as wrap around artifact)
- starry sky artifact

2. MRI software

- slice-overlap artifact (also known as cross-talk artifact)
- cross excitation

3. Patient and physiologic motion

- phase-encoded motion artifact
    - ventricular CSF pulsation artifact
- entry slice phenomenon.

4. Tissue heterogeneity and foreign bodies

- black boundary artifact
- magic angle effect
- magnetic susceptibility artifact
    - blooming artifact
- chemical shift artifact
- dielectric effect artifact.

5. Fourier transform and Nyquist sampling theorem

- Gibbs artifact/truncation artifact
- zero-fill artifact
- 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 artifacts can be related to hardware or software problems, either in the scanner itself or in the shield.

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 -

The Zipper artifact appears as a dense dashed line that cuts across the image perpendicular to the frequency encoding direction.

CAUSE-

due to external RF entering the room at a frequency that matches the expected frequency in the echo. by operating the scanner with the magnetic room door open or through the hole in the RF cage.

REMEDY -

Always close the magnetic room door during data collection. Call an engineer to identify any violations in the RF shield and correct them.

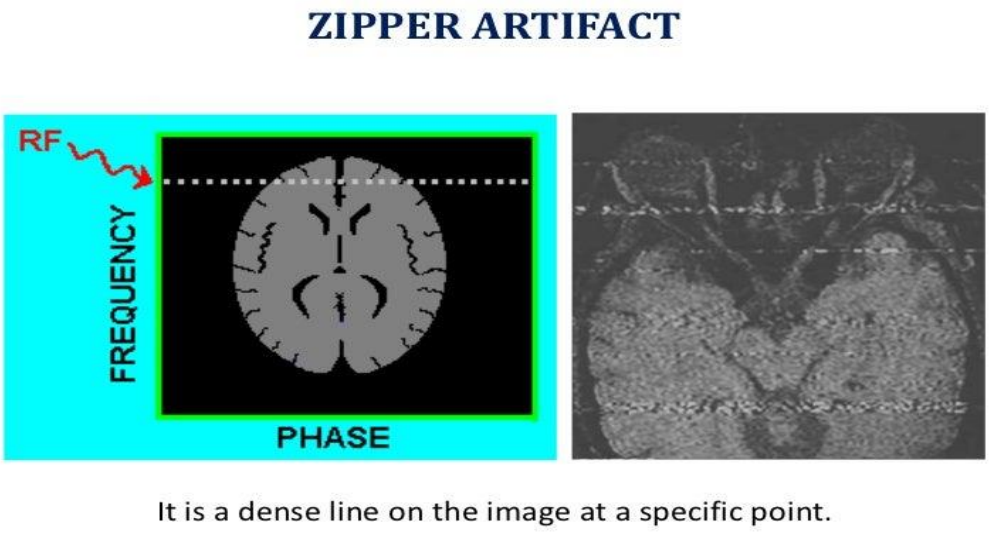

Figure 2 zipper Artifact

B. HERRINGBONE ARTIFACT

A herringbone artifact, also known as a spike, cross, or velvet artifact, is an MRI artifact involving one or more outlier data points in K space.

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.

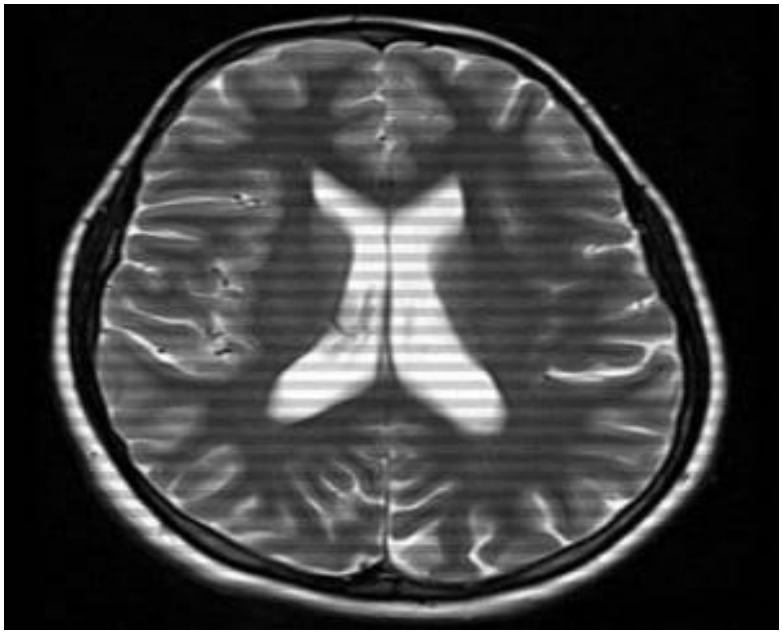

Figure 3 Herringbone Artifact

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.

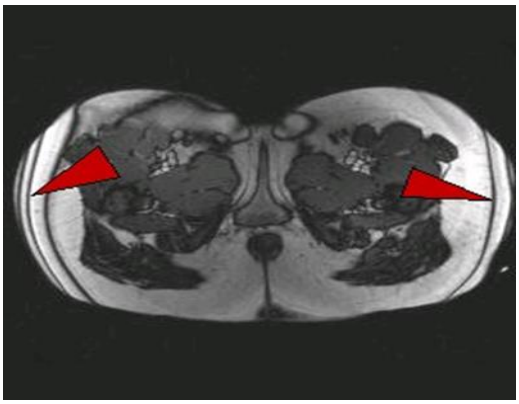

Figure 4. MOIRÉ FRINGES ARTIFACT

D. CENTRAL POINT ARTIFACT

The midpoint artifact is the focal point of the increased signal in the centre of the image.

APPEARANCE - bright spot in the centre of the image.

CAUSE-

This is due to the constant DC voltage offset in the receiver. After the Fourier transform, this continuous shift produces a bright spot in the centre of the image.

The axial MRI image of the head shows a midpoint pseudo-point projected onto the bridge in the centre of the image.

REMEDY-

- the repetition of the sequence can remove artifacts.
- maintain a constant temperature in the scanner and equipment room for the receiver amplifier.
- the software estimates the DC offset and adjusts the data in k-space.
- call service engineer for recalibration

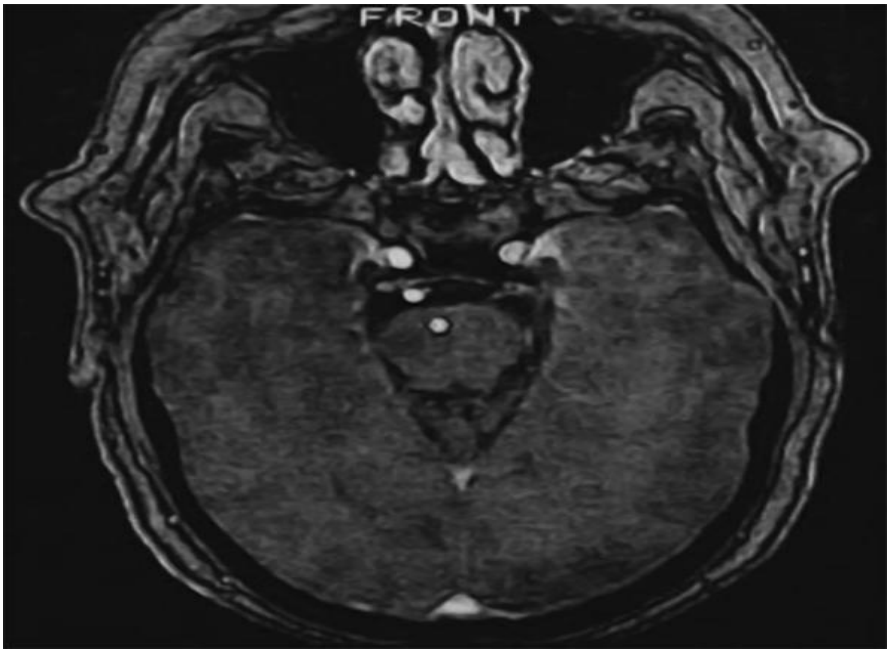

Figure 5 Central - Point Artifact

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. Post-processing methods also exist but can be time consuming.

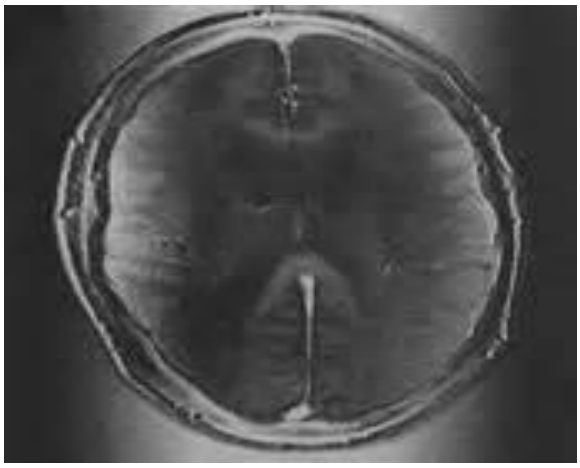

Figure 6 Rf overflow Artifact

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

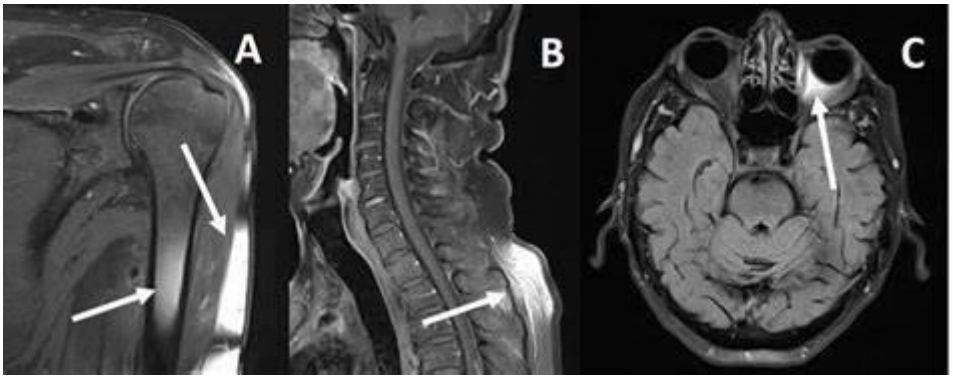

Figure 7 . INHOMOGENEITY ARTIFACT

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:

• Uneven excitation of the nucleus in the field; because RF pulses are applied at flip angles other than 90 and 180 degrees
• Unusual coil load or coil coupling at one point (such as when a tall patient touch one side of the coil)
• magnetic field heterogeneity
• analog-to-digital converter overflow.

REMEDY -

• Precise roll feed
• use a coil sized appropriately for the size of the patient and the part being examined
• prevent the patient from touching the coil (you can use a sponge between the patient and the coil)
• wedges to reduce magnetic field heterogeneity
• Use the appropriate sweep parameters to set the appropriate amplitude of the applied RF pulses (less gain to avoid analog-to-digital converter overflow).

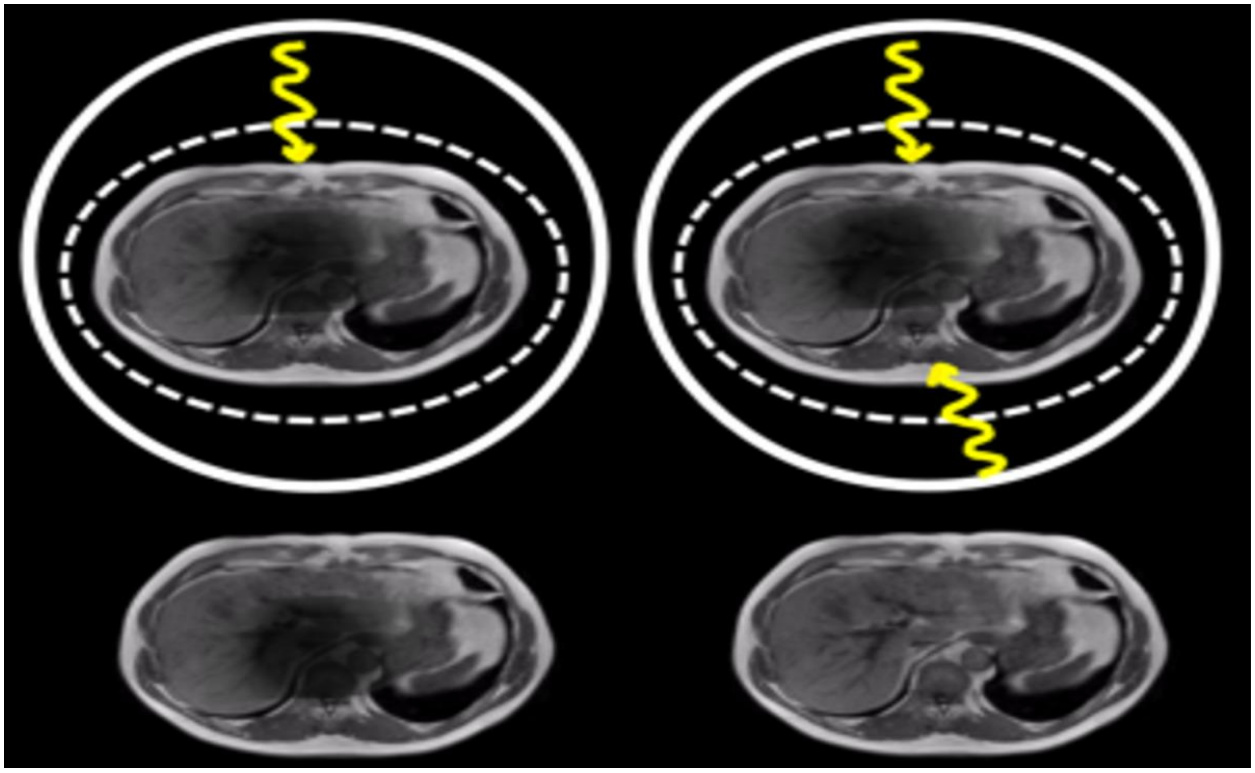

Figure 8 Shading Artifact

H. ALIASING ARTIFACT

APPEARANCE - An alias in MRI, also known as surround, is a common MRI phenomenon that occurs when the field of view (FOV) is smaller than the part of the body being imaged. The part of the body that is outside the edge of vision is projected on the other side of the image.

CAUSE - Anatomy outside the field of view is still subject to the gradient and produces a signal if it is within the receiving range of the receiver coil. The signal from this anatomy has a frequency higher or lower than the FOV because the nuclei are localized on parts of the gradient beyond the FOV. If the frequency exceeds the Nyquist frequency, then that frequency is not digitized correctly and is expressed as a lower frequency. Frequency wrap Aliasing along the frequency encoding axis is called frequency wrapping. When the field of view is smaller than the anatomical structure in the image frequency direction, frequencies outside the field of view will be higher than the Nyquist frequency and mapped to a lower frequency. This is known as high frequency aliasing.

Phase Return Aliasing along the phase axis of the image is called phase return. This is due to the sampling of the data along the phase axis of the image. Signals coming from outside the FOV in phase direction are assigned a phase value and thus a spurious frequency has been assigned to signals coming from within the FOV.

REMEDY -

- enlarged field of view (FOV)
- Use pre-saturation band in out-of-field areas
- Anti-aliasing software
- phase direction and frequency conversion
- use surface coils to reduce signals out of the region of interest.

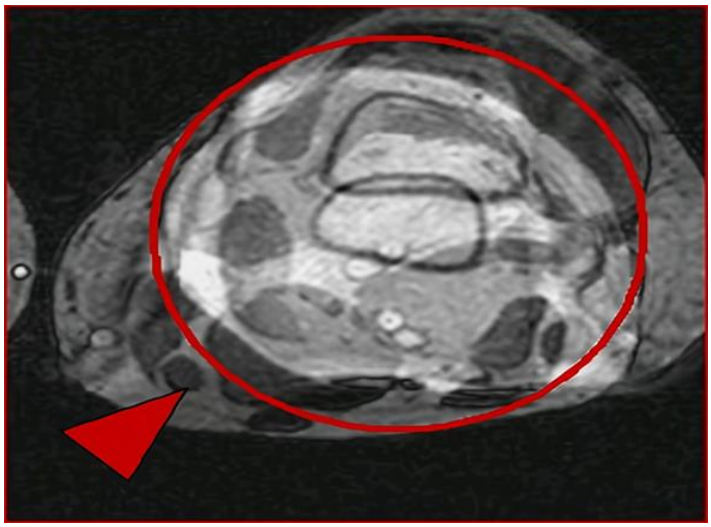

Figure 9 Aliasing Artifact

I. STARRY-SKY ARTIFACT

APPEARANCE – Starry sky artifacts in parallel MRI imaging (such as SENSE) are relatively common and usually manifest as an uneven distribution of image noise, usually affecting the central portion of the image (farther from the surface coils). surface texture.

CAUSE – The noise in parallel imaging is unevenly distributed, but highly dependent on the spatial parameter, the geometric factor (g). It also increases with a higher acceleration factor (R). The result is an uneven distribution of areas with low signal-to-noise ratio (SNR). Areas far from the surface coil (e.g., deep tissue in large patients) are more prone to this artifact.

REMEDY – Adjusting the R factor downward while scanning improves the SNR, but significantly increases the scan time. Artifacts may be reduced by simply repeating the sequence

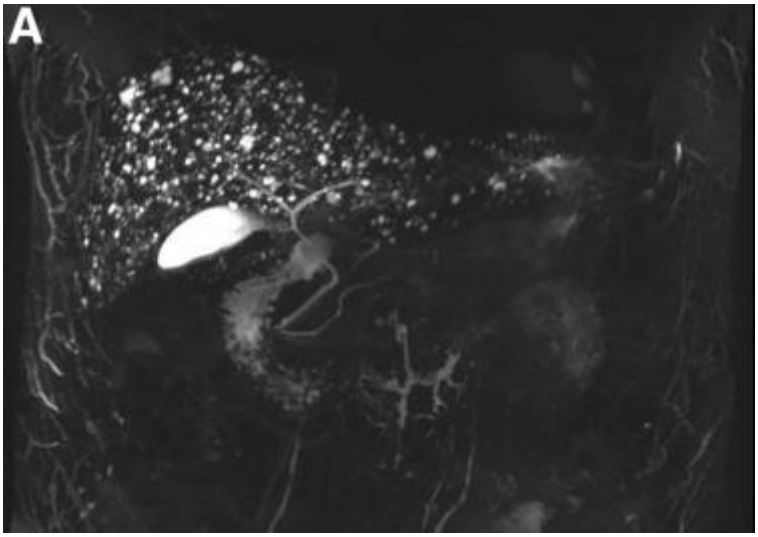

Figure 10 Stary Sky Artifact

2. MRI SOFTWARE

A. SLICE-OVERLAP ARTIFACT (ALSO KNOWN AS 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. Do not confuse this with cross-excitation, which has similar causes. Cross-excitation is not due to image distortion.

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. A dark horizontal band at the bottom of the axial image through the next lumbar vertebra highlights this artifact.

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.

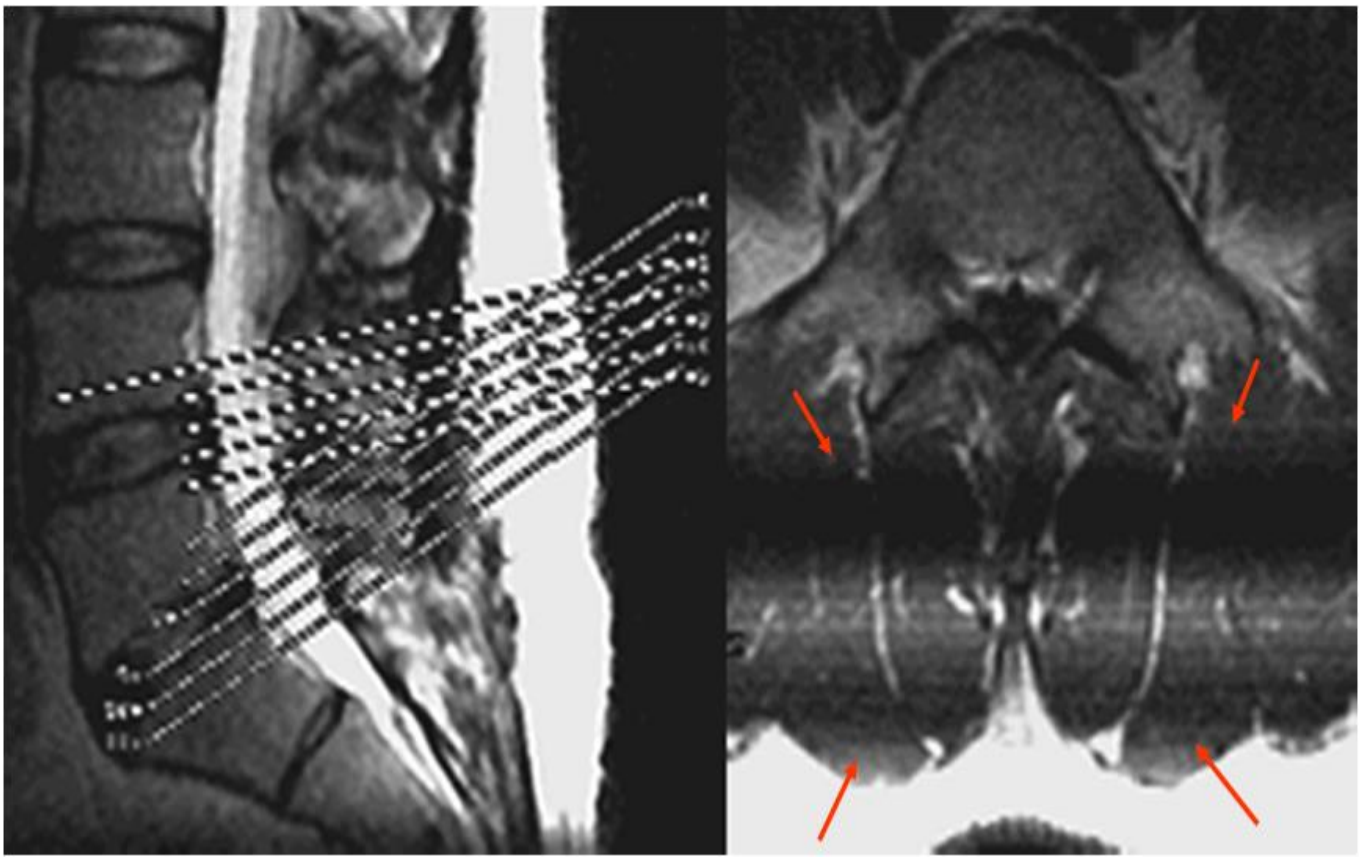

Figure 11 Slice Overlap Artifact

B. CROSS EXCITATION

APPEARANCE – Cross-excitation artifact is a type of MRI artifact that refers to signal loss within one slice due to pre-excitation by RF pulses directed to adjacent slices.

CAUSE - The frequency profile of the RF pulse is incomplete. This means that when a slice is selected, neighbouring slices are also excited to some extent. If this adjacent slice is imaged during the same TR (i.e., multi-slice imaging) or shortly thereafter (i.e., gapless imaging), it will initially be partially saturated and the resulting signal will decrease. This phenomenon becomes more pronounced in the inversion recovery (180°) sequence.

REMEDY -

- When imaging adjacent layers, maintain a minimum distance of 1/3 of the layer thickness.
- Nesting between slices
- Using 3D imaging when volumetric imaging is required
- Use an optimized pulse sequence with a high minimum TE and a time penalty that reduces the number of slices for a given TR.

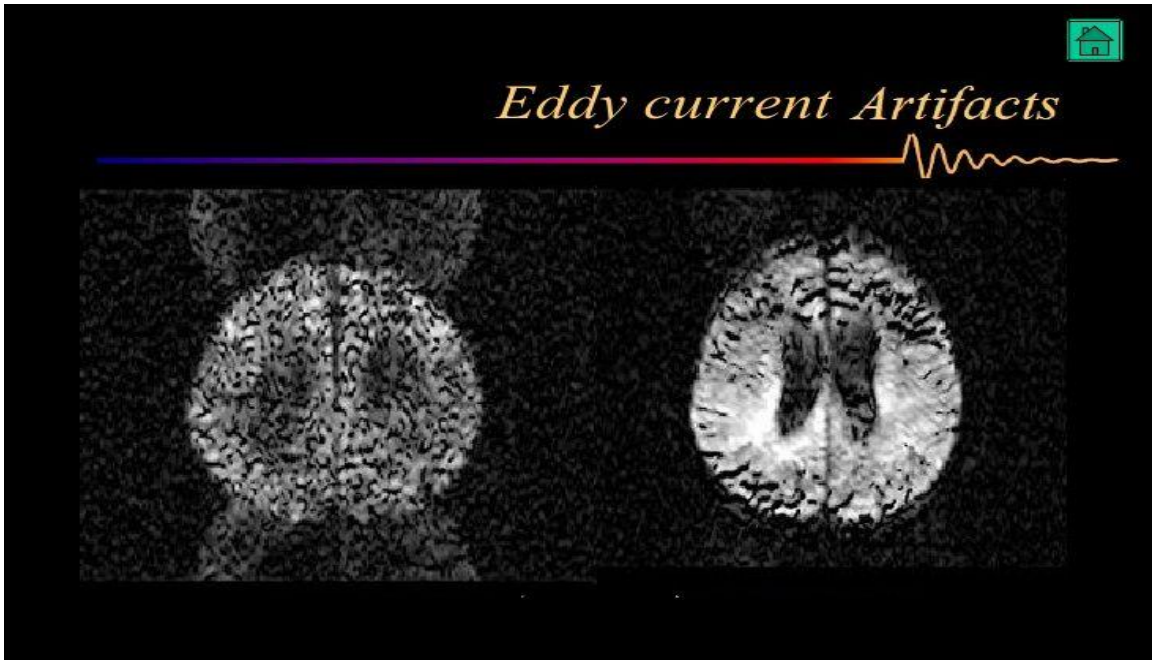

Figure 12 Cross Excitation Artifacts

3. PATIENT AND PHYSIOLOGIC MOTION

A. PHASE-ENCODED MOTION ARTIFACT

APPEARANCE - results from tissue/fluid movement during scanning. It appears as a ghost image in the direction of the phase-encoding, usually in the direction of the short axis of the image (i.e., left-to-right in the axial or coronal brain and front-to-back in the axial abdomen).

CAUSE – These artifacts can be observed through the patient's arterial pulsation, swallowing, breathing, peristalsis, and body movements. 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 distance between these ghosts depends on the repetition time (TR) and frequency of movement.
Motion artifacts can be distinguished from Gibbs and truncation artifacts because motion artifacts span the entire field of view (FOV), as opposed to truncation artifacts, which abruptly decrease away from the boundary that causes them.

Here's how to identify phase artifacts:

1. Identify known moving/flowing structures and verify that the artifacts match them (horizontal or vertical depending on phase-encoding orientation).
2. Adapt the shape of the ghost to the shape of the flowing vessel (eg, a circular pseudolesion with an aortic ghost).
3. Large window for observing repeated ghosts outside anatomical boundaries.
4. These are distinguishable from Gibbs and truncation artifacts, as they span the entire field of view, unlike truncation artifacts, which abruptly decrease away from the causative boundary.

REMEDY-

- Cardiac/respiratory gate
- Spatial pre-saturation bands placed over moving tissue (eg, over the anterior neck of the sagittal cervical spine)
- Place a spatial pre-saturation band outside her FOV, especially before the entrance layer or after the exit layer, to reduce ghosting due to vascular flow.
- arteries and veins
- Scans tend to reduce abdominal range of motion
- 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.

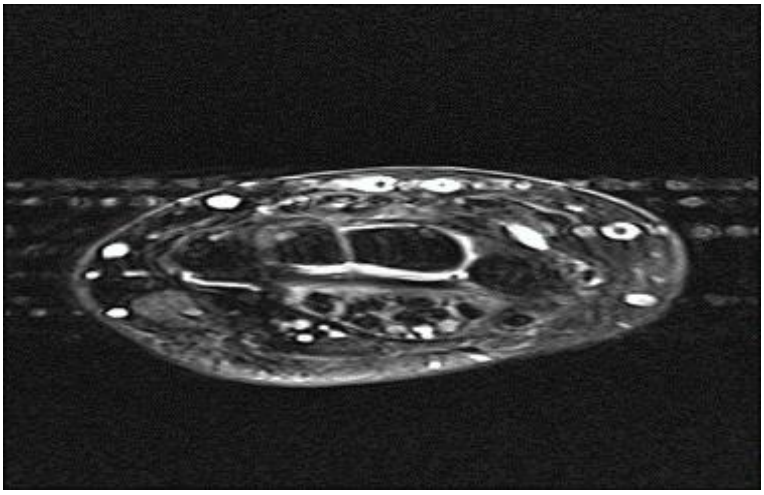

Figure 13 Phase - Encoded Motion Artifact

- **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.

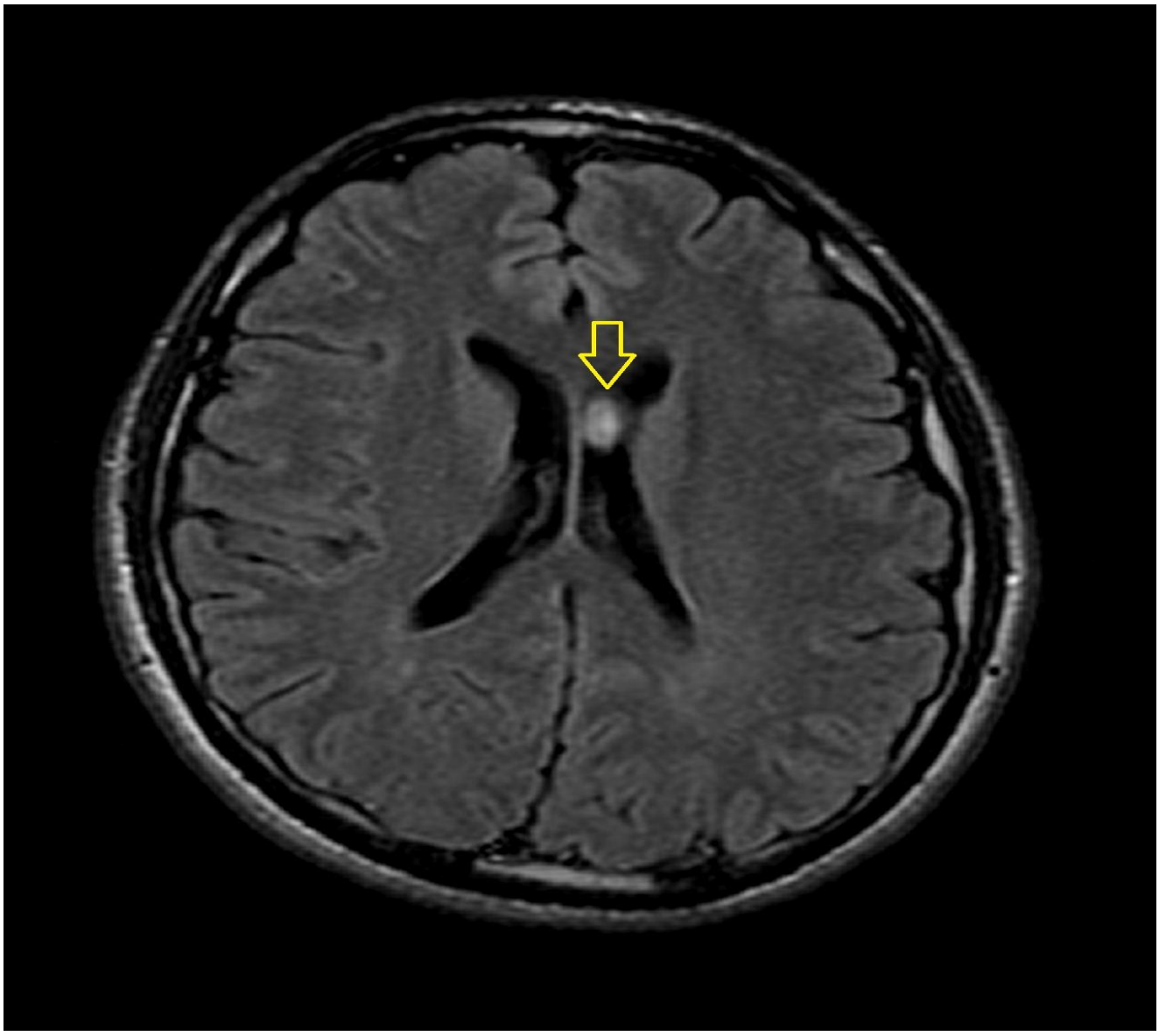

Figure 14 VENTRICULAR CSF PULSATION ARTIFACT

B. ENTRY SLICE PHENOMENON

The entry slice phenomenon is a phenomenon that occurs when unsaturated spins in blood first enter one or more slices.

APPEARANCE - Characterized by a bright signal at the cut plane where the blood vessel (artery or vein) first enters. 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. Characteristic positions and, if necessary, the use of gradient echo flow techniques can be used to distinguish entrance slice artifacts and occlusions.

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

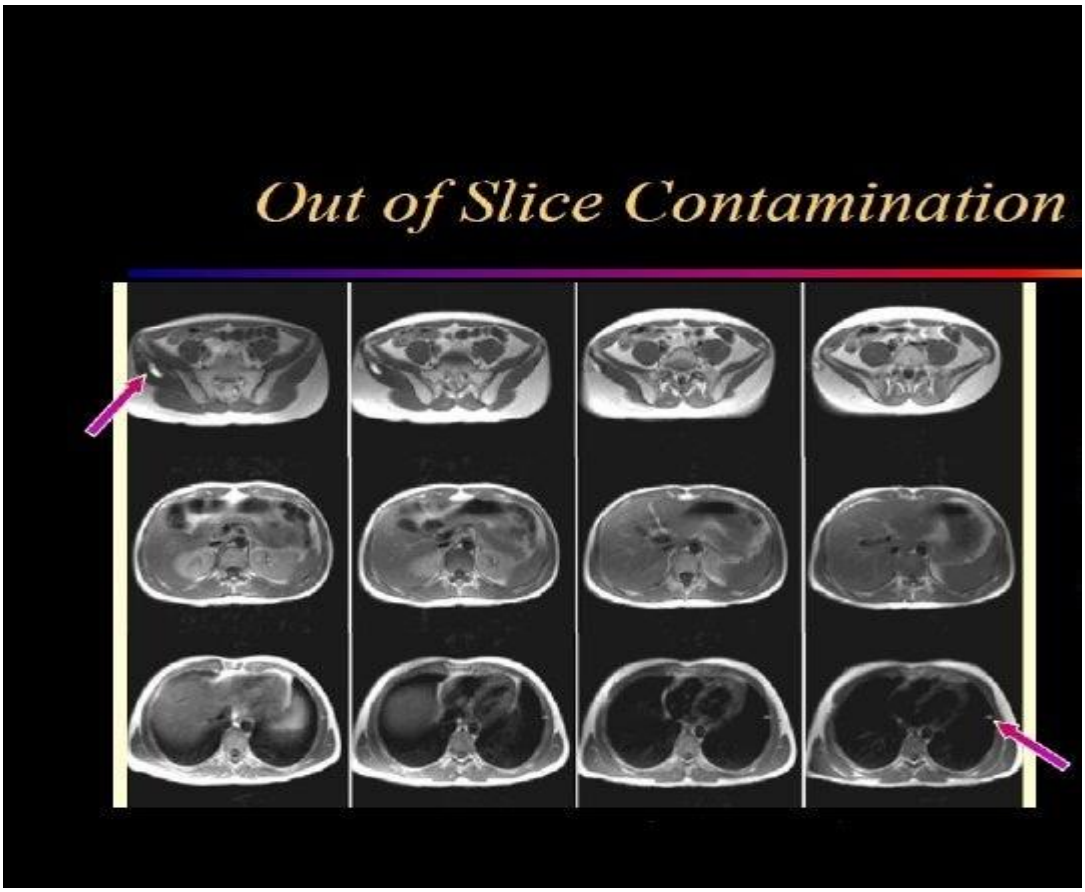

Figure 15 Entry - Slice Phenomenon Artifact

4. TISSUE HETEROGENEITY AND FOREIGN BODIES

A. BLACK BOUNDARY ARTIFACT

Black border artifact. Also known as ink artifacts or Type 2 chemical shift artifacts.

APPEARANCE - This is the artificially created black line found at the interface between fat and water, such as between muscle and fat. This 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 as a result of choosing echo times (TE) in a gradient echo (GE) sequence in which fat and water rotations (located within the same voxel of intersection) cancel each other 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. This artifact does not occur in spin-echo (SE) sequences because the spins are rephased by a 180degree refocusing gradient.

REMEDY-

- Select TEs around 4.5 ms, 9 ms, and 13.6 ms.
- Fat suppression available
- Use SE sequences instead of GE.

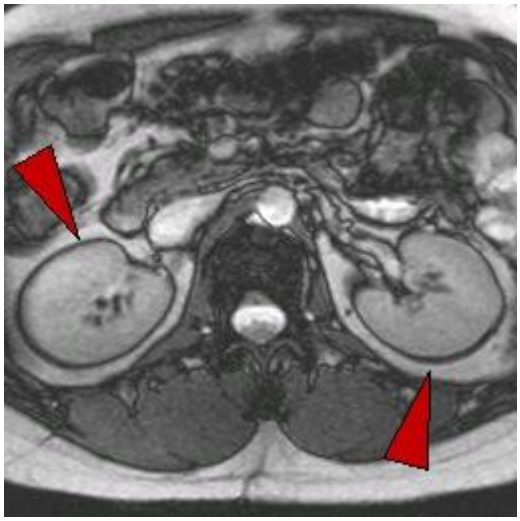

Figure 16 BLACK BOUNDARY ARTIFACT

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 8.32 and mimics the pathology.

CAUSE-

This artifact is caused by the special physical properties of fibrous tissue and its interaction with static magnetic fields. Water molecules in contact with structured collagen Fibers (tendons, ligaments, nerves, menisci, etc.) exhibit dipolar interactions that shorten the T2 relaxation time. The extent of these interactions varies with the angle of the Fiber with respect to the field axis B^0. Maximum at angles 0° and 90°, minimum at 55°.

The underlying short T2 relaxation times of tendons and ligaments associated with dipolar interactions are responsible for the usual low signal in these structures. However, the T2 relaxation times are longer and maximal when these fibrillar structures are at a 55° angle to B^0, resulting in a hypersignal of varying intensity.

REMEDY-

The intensity of jitter induced by the magic angle varies with PD.

It is maximum for relatively short TEs (around T2) and decreases with longer TEs. The relative hypersignal change is angle dependent and increases gradually between 0° and 55°. The magic angle has virtually no effect on T1 relaxation time. Therefore, the T1 weighting sequence is less affected.

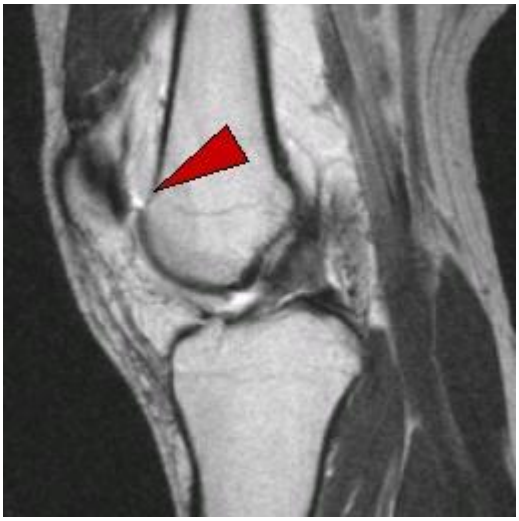

Figure 17 Magic Angle Artifact

C. MAGNETIC SUSCEPTIBILITY ARTIFACT

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

CAUSE-

Magnetic susceptibility corresponds to the internal magnetization of tissue resulting from interaction with an external magnetic field. Placing two tissues with different magnetic susceptibilities next to each other produces a local distortion of the magnetic field. Such natural interfaces exist between air and tissue or between trabecular bone and tissue.

These static magnetic field inhomogeneities (T2*) cause dephasing and frequency shifts of adjacent spins. This leads to artifacts in the MR images, primarily loss of signal, but also image distortion.

The presence of metals (ferromagnetic or not) causes large distortions in the magnetic field and significant susceptibility artifacts. The range of signal loss depends on the metal and the pulse sequence (spin echo, gradient echo). The explanation for this signal loss is:

• Local magnetic field inhomogeneities (T2*) that accelerate transverse relaxation and signal decay

• The magnetic field is distorted such that a precession frequency shift occurs.

o when slice selection is performed and no spin excitation or signal occurs

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

REMEDY-

• Spin echo sequences are less susceptible to susceptibility artifacts than gradient echo sequences. In SE, a 180° refocusing pulse corrects the susceptibility-induced spin dephasing (belonging to the T2* effect).

• Swapping the direction of frequency and phase encoding modifies the susceptibility artifacts without removing them.

• Short TE reduces dephasing time and reduces signal loss.

• A large receiver bandwidth (strong slope) reduces the minimum available TE.

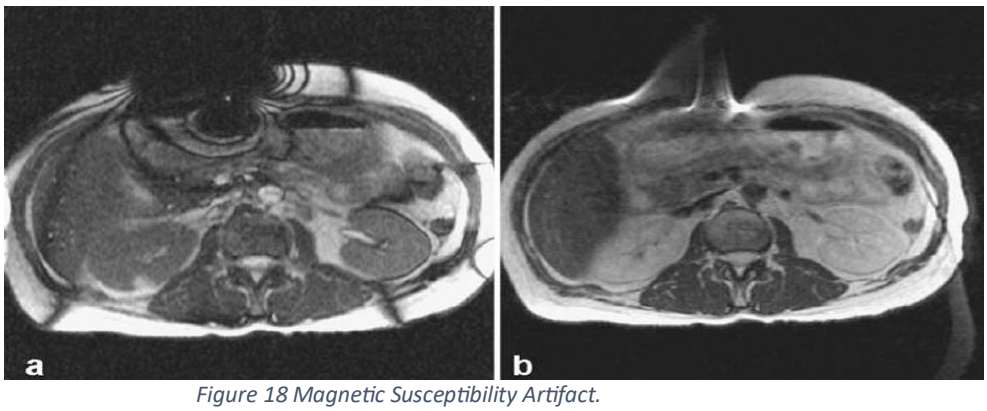

Figure 18 Magnetic Susceptibility Artifact.

o **BLOOMING ARTIFACT**

Blooming artifacts are magnetic susceptibility artifacts that appear in some MRI sequences in the presence of paramagnetic substances that affect the local magnetic environment. Although an artifact, it can be particularly exploited to improve detection of certain small lesions, similar to how the T1-shortening effect of low concentrations of gadolinium is used to detect contrast enhancement.

One of the most powerful and widely used sequences to maximize blooming artifacts to great effect is susceptibility-weighted imaging (SWI). Gradient echo and low B-value diffusion-weighted imaging are also useful in the absence of a dedicated susceptibility-weighted sequence.

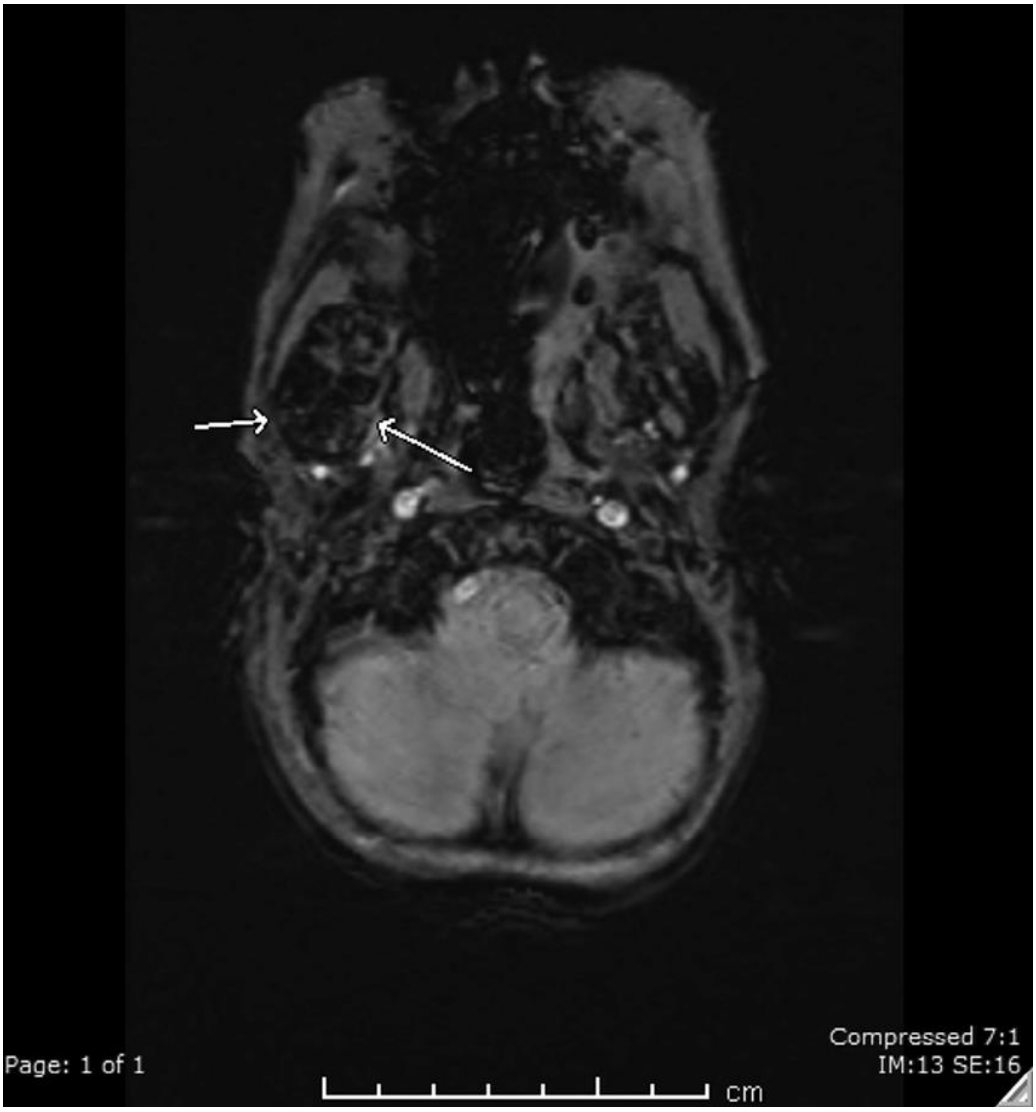

Figure 19 Blooming Artifact.

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.
• MRI may show chemical shift misalignment or mismatch (Type 1 chemical shift artifact) in both spin echo (SE) and gradient echo (GE) sequences. 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 addition to mismatches, GE sequences may exhibit another type of chemical shift artifact known as black border or ink artifact (Type 2 chemical shift artifact). This artifact causes black lines in all directions at the fat-water interface. In pixels with approximately equal amounts of fat and water, the fat and water spins are 180° out of phase at a given echo time due to chemical shift or frequency difference, resulting in signal cancellation.

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.

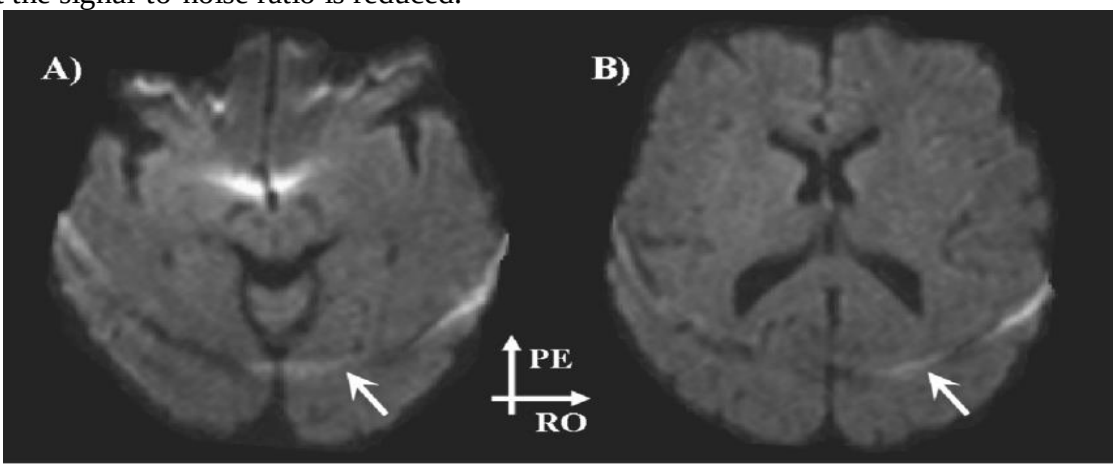

Figure 20 Chemical - Shift Artifact

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.

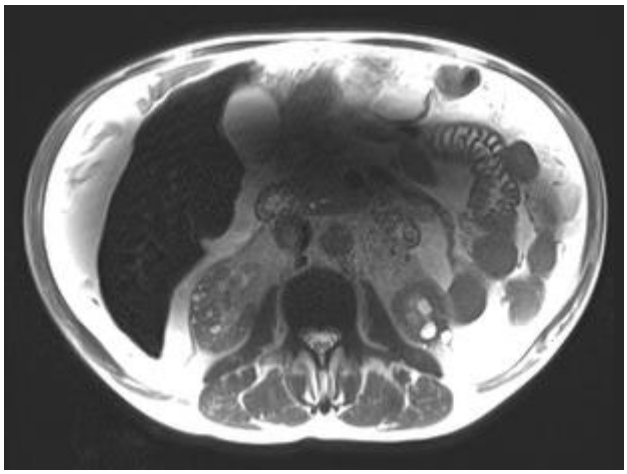

Figure 21 Dielectric Effect Artifact.

5. FOURIER TRANSFORM AND 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 - This artifact is caused by under-sampling the data (too few k-space lines are filled in), which erroneously shows the intersection of high and low signals in the image. This most commonly occurs when the tissue is still producing high signal at the end of data acquisition, or when echo peaks are not centred in the middle of the sampling window. The latter is common when using very short TEs.

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.

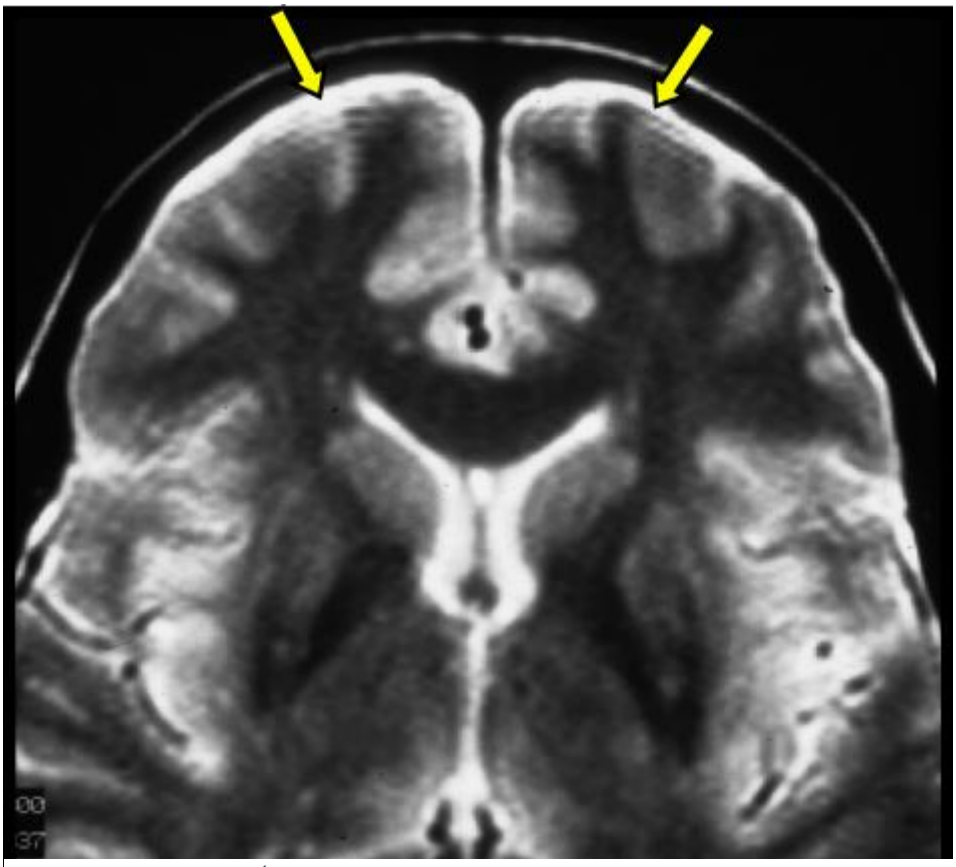

Figure 22 GIBBS ARTIFACT/TRUNCATION ARTIFACT

B. ZERO-FILL ARTIFACT

Zero-fill artifacts are one of many MRI artifacts and are caused by the missing or zeroing of data in the k-space array during scanning.

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.

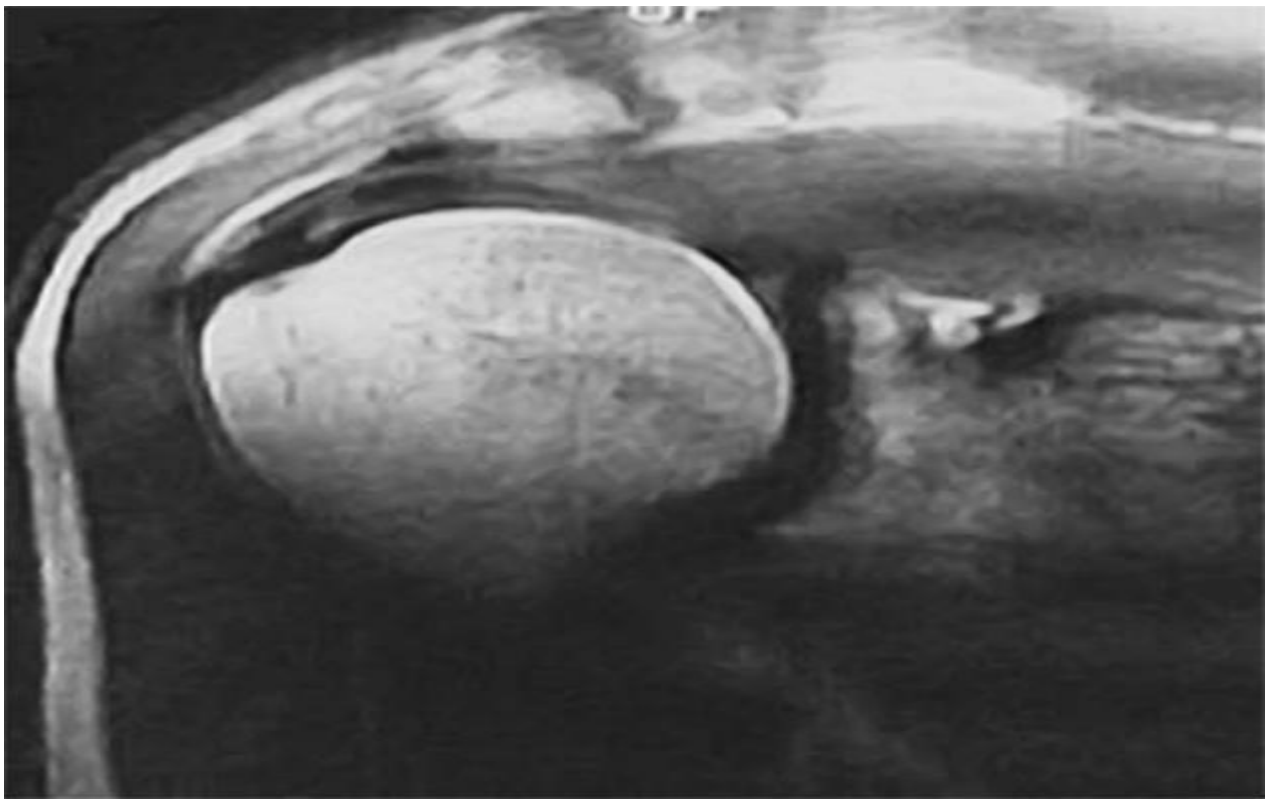

Figure 23 Zero - Fill Artifact

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 - The spatial encoding of objects outside the FOV is corrupted and indistinguishable from objects inside the FOV. This creates a spatial mismatch on the opposite side of the image. Although this artifact can occur in both the frequency-encode and phase-encode directions, it is really only a problem in the phase-encode direction.

Valid phase values range from -180° to +180°. It can be expressed as an angle corresponding to a position on a circle. A phase of 180° corresponds to -180°, 200° corresponds to -160° (200° - 360°), and 220° corresponds to -140°.

In phase encoding, the phase of spins changes in the direction of the slice plane. A phase shift between -180° and +180° in the first coding step is assigned to cover the field of view. Subsequent phase encoding steps use larger ranges, which are always multiples of -180°/+180° (-360°/+360°, -540°/+540°, etc.). If the object extends outside the field of view, there will be a phase shift (because the phase encoding gradient is applied across the body), but its value will be out of range.

REMEDY-

There are many ways to manage aliases. One of his ways of dealing with wraparound is to swap the directions of frequency encoding and phase encoding so that the direction of phase encoding aligns with the short dimension of the body part being imaged. The advantage is that this alignment requires fewer phase-encoding steps and allows the use of rectangular arrays with the same spatial resolution. However, it also modifies other artifacts (ghosting, chemical shift artifacts, etc.), which limits the usefulness of this technique. If the FOV completely encompasses the body part under examination in the phase encoding direction, no aliasing will occur. However, to increase the field of view and maintain the same spatial resolution, the number of phase-encoding steps must be increased, resulting in a loss of acquisition time.

The phase-less wrap method removes aliasing without sacrificing temporal or spatial resolution, but at the expense of signal-to-noise ratio. It combines:

• FOV doubling in phase encode direction

• Double the number of phase encoding steps (to keep the same spatial resolution)

• Halve the number of averages (to keep the same scan time while reducing the signal-to-noise ratio).

• 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. To avoid frequency aliasing, the sampling rate of the MR signal should be at least twice the highest expected frequency. This critical sampling rate is called the Nyquist frequency.

Modern MR scanners remove frequency aliasing by:

• Oversampling of data during digitization of MR signals

• and/or use a bandpass filter to remove high frequencies.

These methods have no disadvantages in terms of scanning time or image quality.

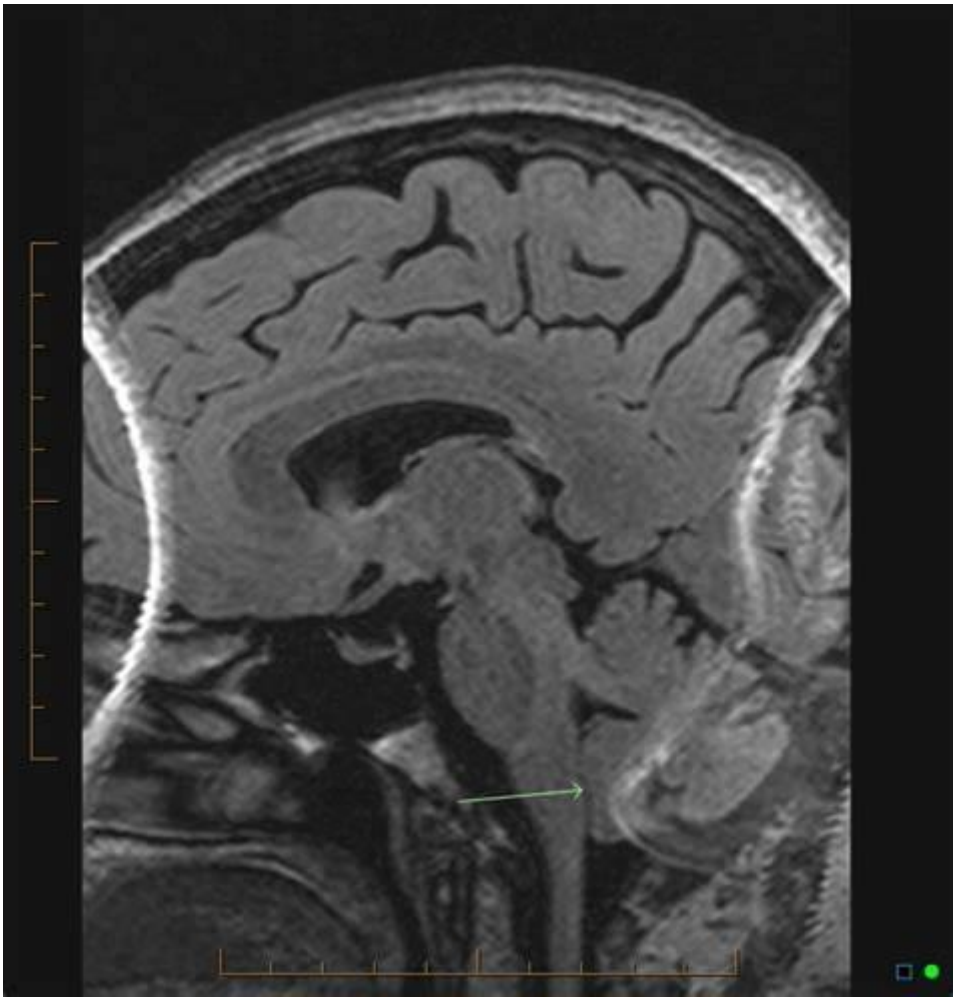

Figure 24 Aliasing/Wrap - around Artifact.

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