Artifacts in MRI

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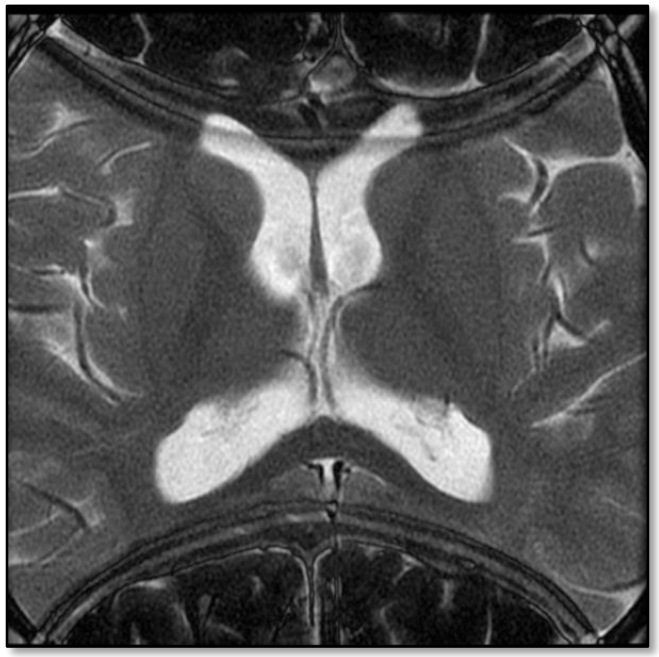
Definition

Artifact: Any irregularity noted in an MR image which is related to the imaging process rather than to an anatomical or physiological abnormality.



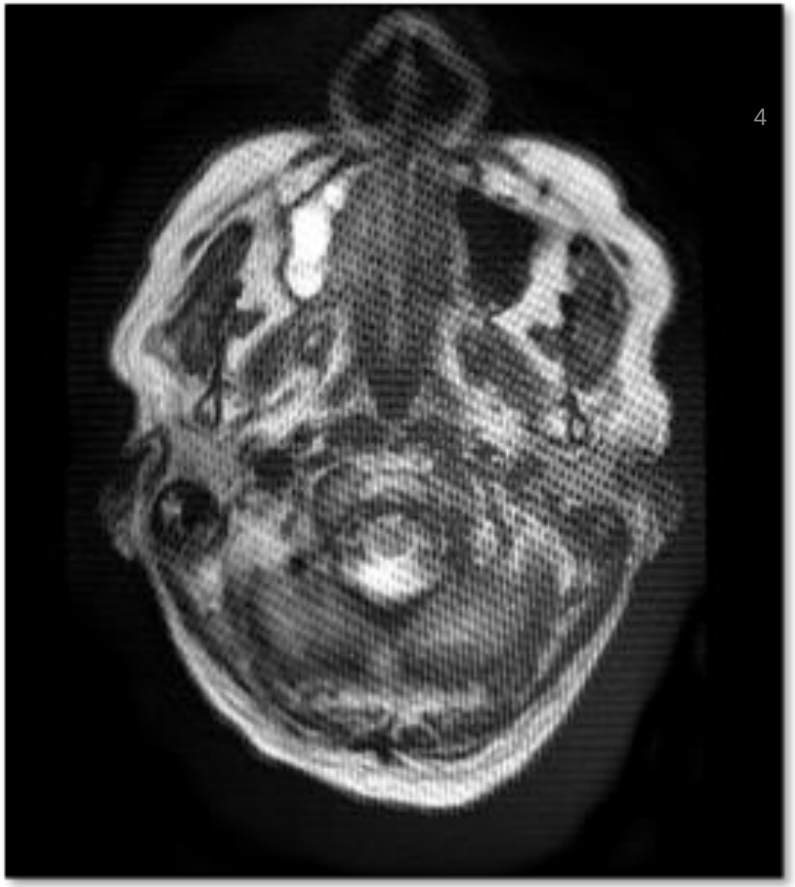
- Clinical artifacts
- Technical artifacts

Clinical artifacts

- Patient related
  - Motion : voluntary and involuntary (breathing, cardiac motion…)
  - Inherent to the patient

- Operator related
  - Bad settings of scan parameters
  - Related to setup and preparation of the patient

Technical artifacts



- Hardware
  - Components and configuration
  - Degradation and malfunction
- Software
  - Release level
- Environment
  - Hospital equipment (spurious RF sources)
  - Moving cars, elevator next to MR room (B0 disturbances)
  - Temperature and humidity
- Physics phenomenoms $f(x) = a_0 + \sum_{n=1}^{\infty} \left(a_n \cos\frac{n\pi x}{L} + b_n \sin\frac{n\pi x}{L} \right)$

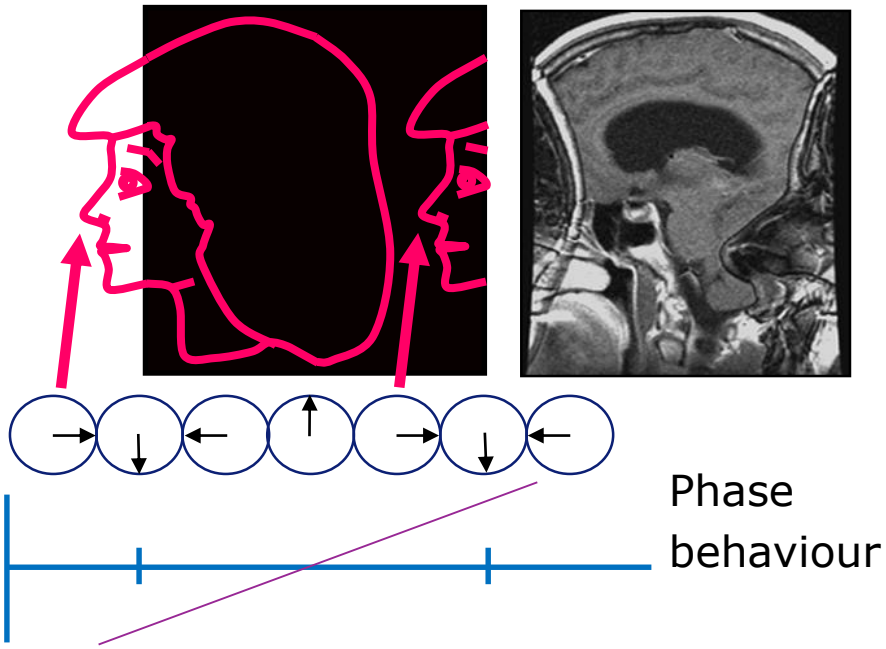
Aliasing Artifact

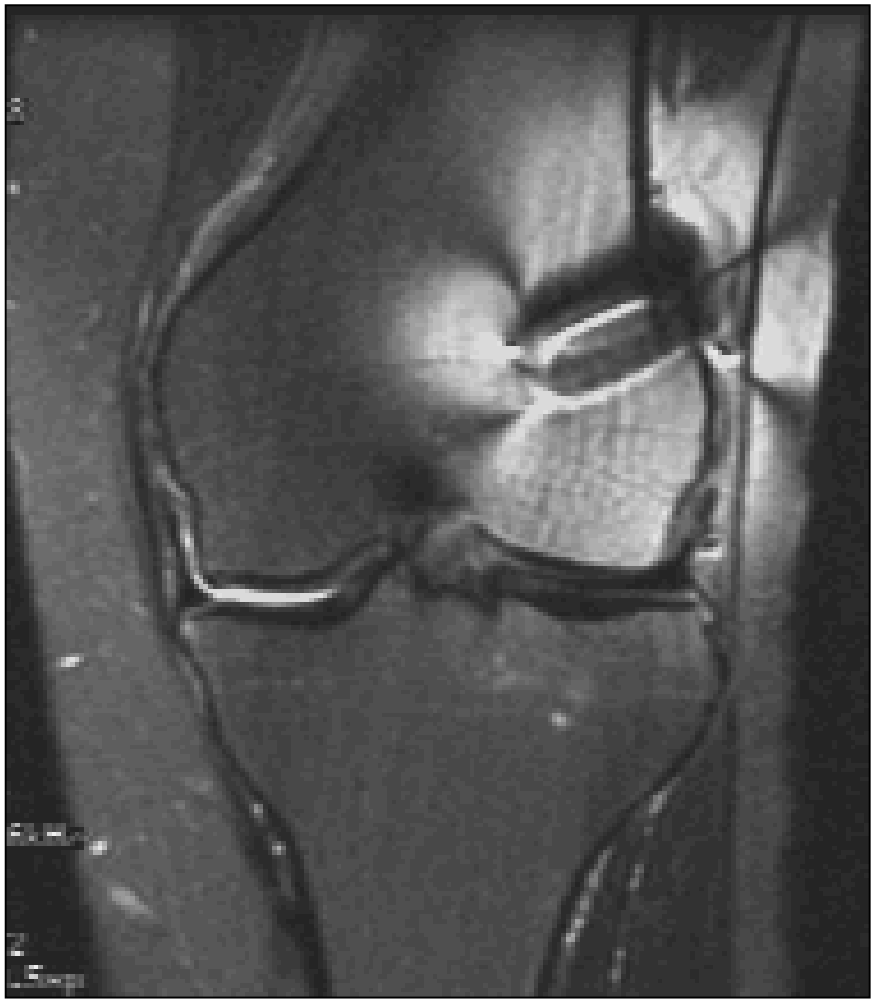
Causes of the aliasing artifact:

- Tissue is outside FOV in phase direction

Recommendations :

- Increase FOV in phase direction
- Change Fold-over direction
- Oversampling



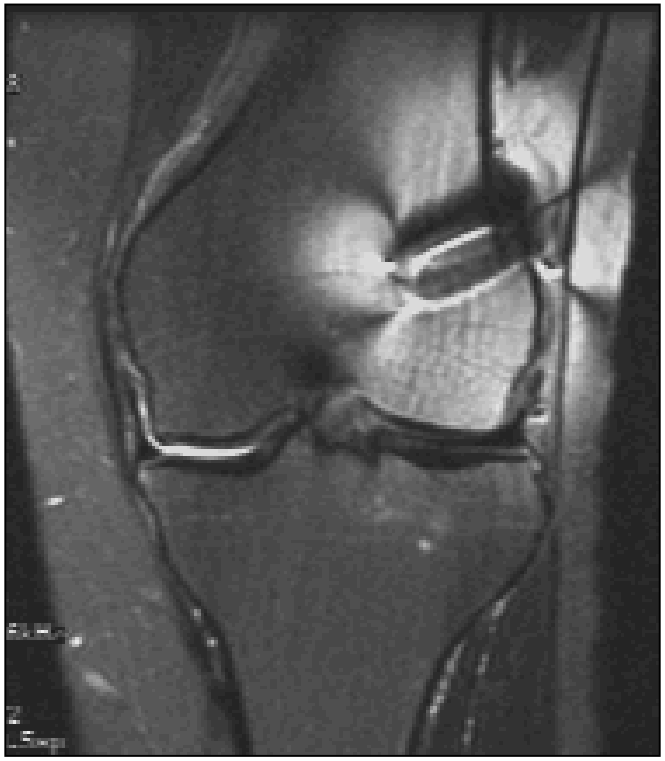


Magnetic Material Artifact

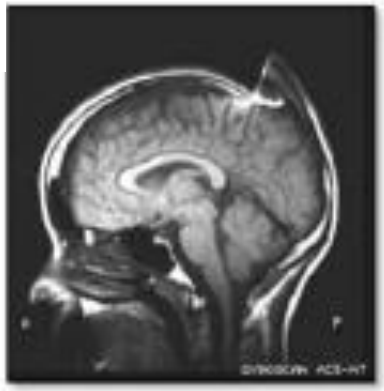
Is caused by ferromagnetic implants

Recommendations :

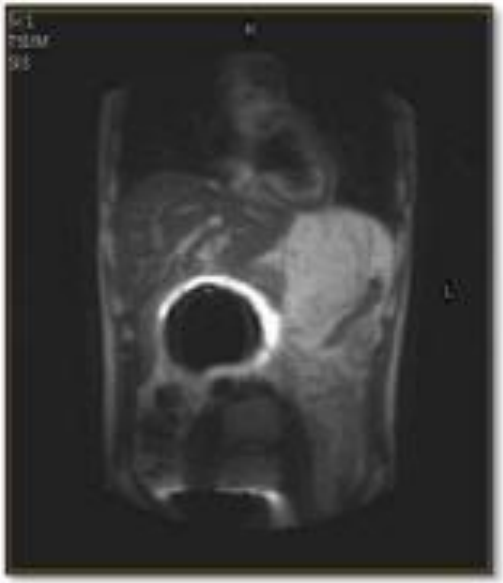
- Reduce water-fat shift
- Adapt fold-over direction
- Volume of shim outside of the metallic area
- Use sequence less susceptible for magnetic material influence
- Reduce voxel size
- Reduce TE
- O-Mar



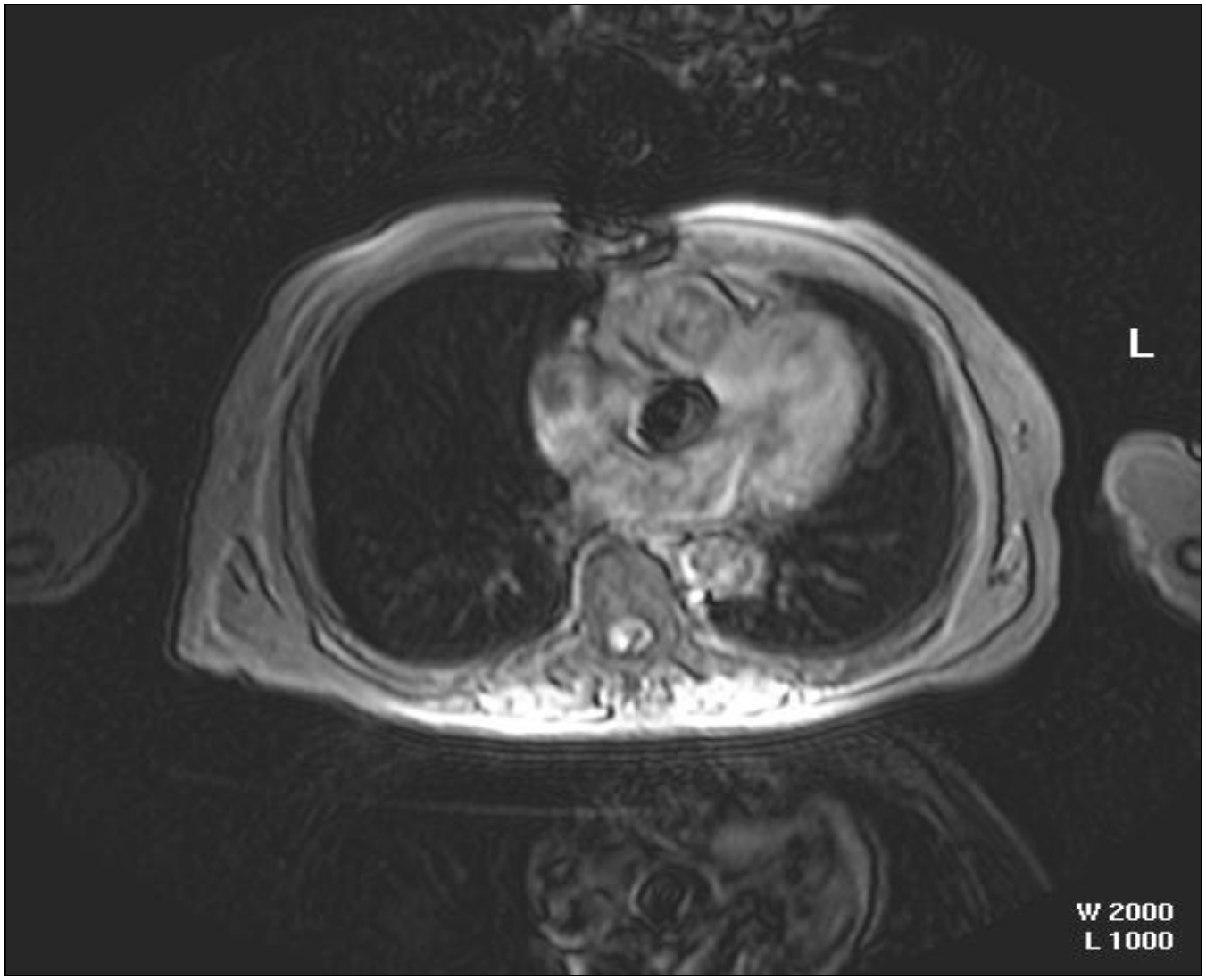
Examples of metallic artifacts origins

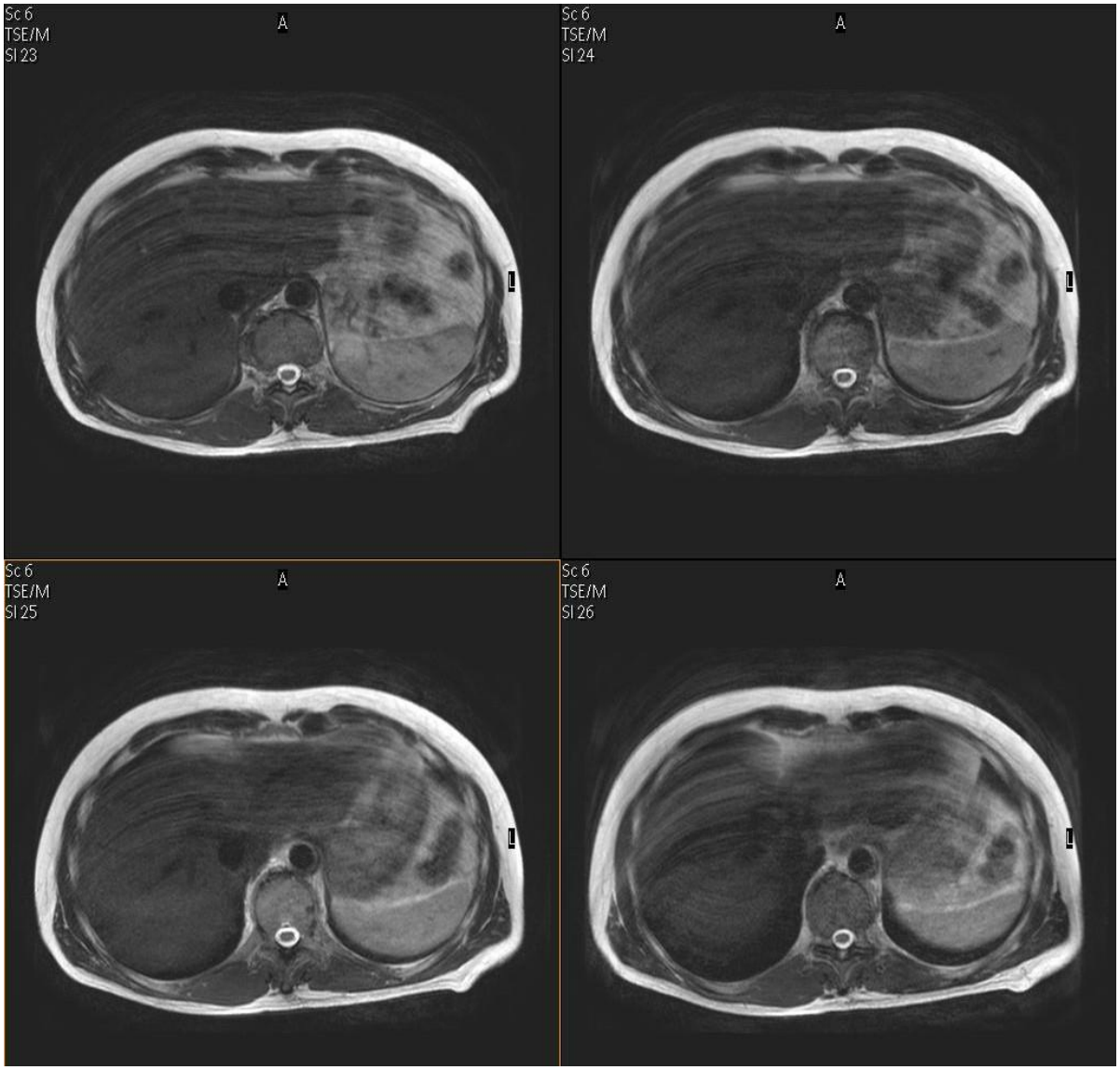


- Internal
  - Surgical clips, staples, shunts
  - Dental implants and appliances
- External
  - Jewelry, buckles
  - Piercings
  - Metallic stitching in clothing
  - Hairpins, some hairpieces, wigs
  - Make-up, tattoo



Warning: these items may also cause a burn risk


L
W 2000
L 1000


Sc 6
TSE/M
SI 23
A
L
Sc 6
TSE/M
SI 24
A
L
Sc 6
TSE/M
SI 25
A
L
Sc 6
TSE/M
SI 26
A
L

Motion Artifacts

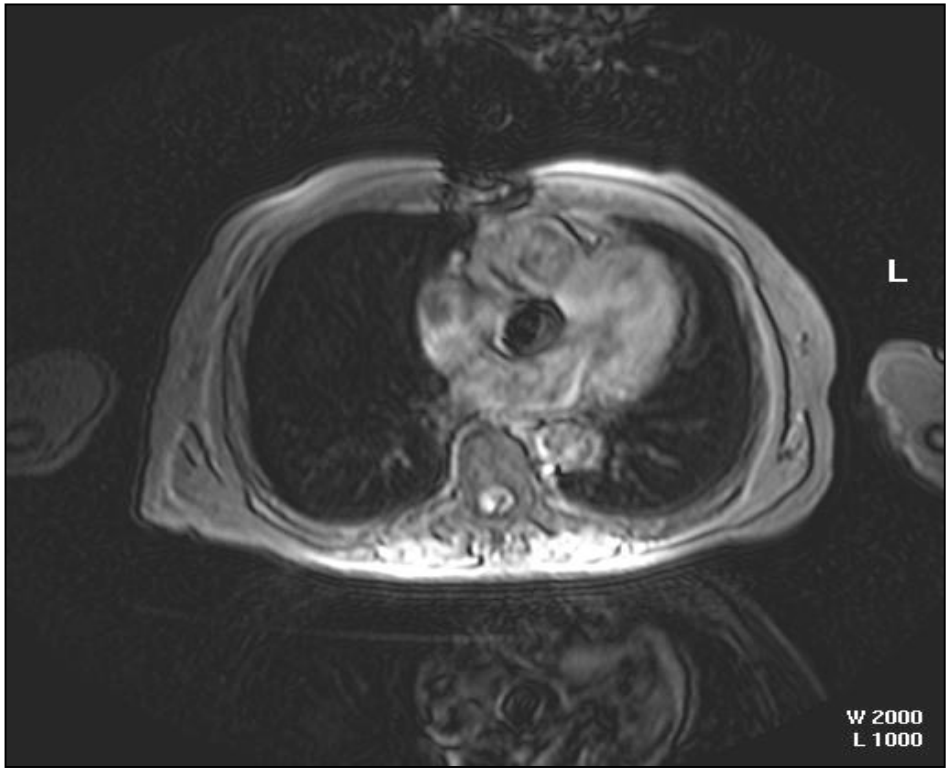
Causes of the motion artifact:

- Involuntary patient movement during acquisition
  - Cardiac motion
  - Respiratory motion
  - Blood flow
  - CSF pulsation
- Patient movement during acquisition

Cardiac Motion Artifacts

Solution for Cardiac motion artifacts:

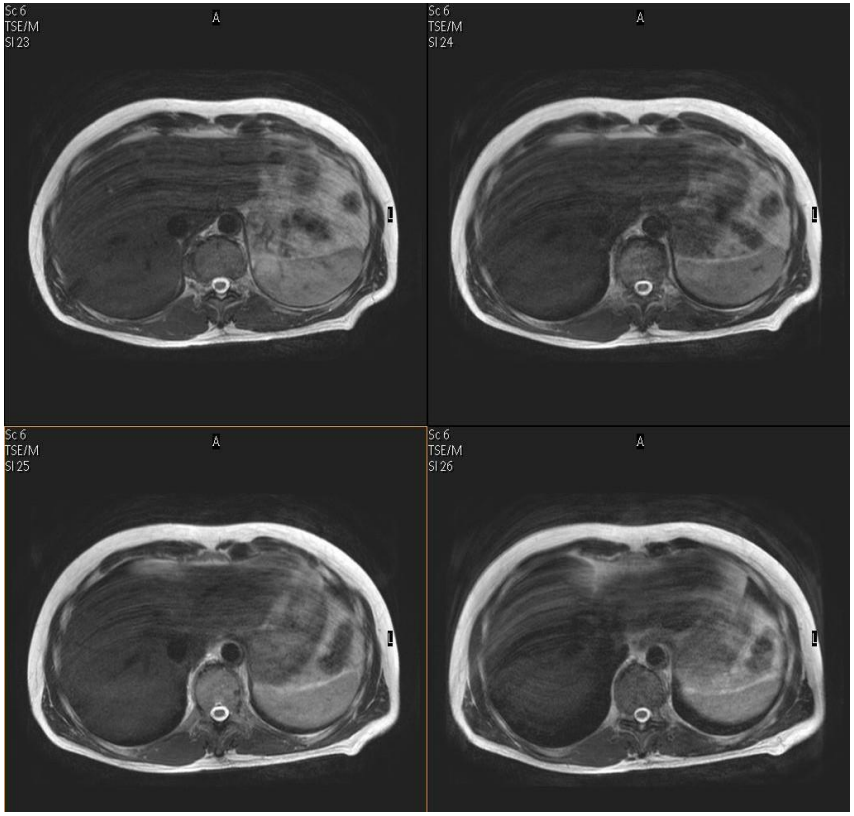
- Cardiac synchronization
- Flow compensation
- Choose appropriate phase direction



Respiratory Motion Artifacts

Solution for Respiratory motion artifacts:

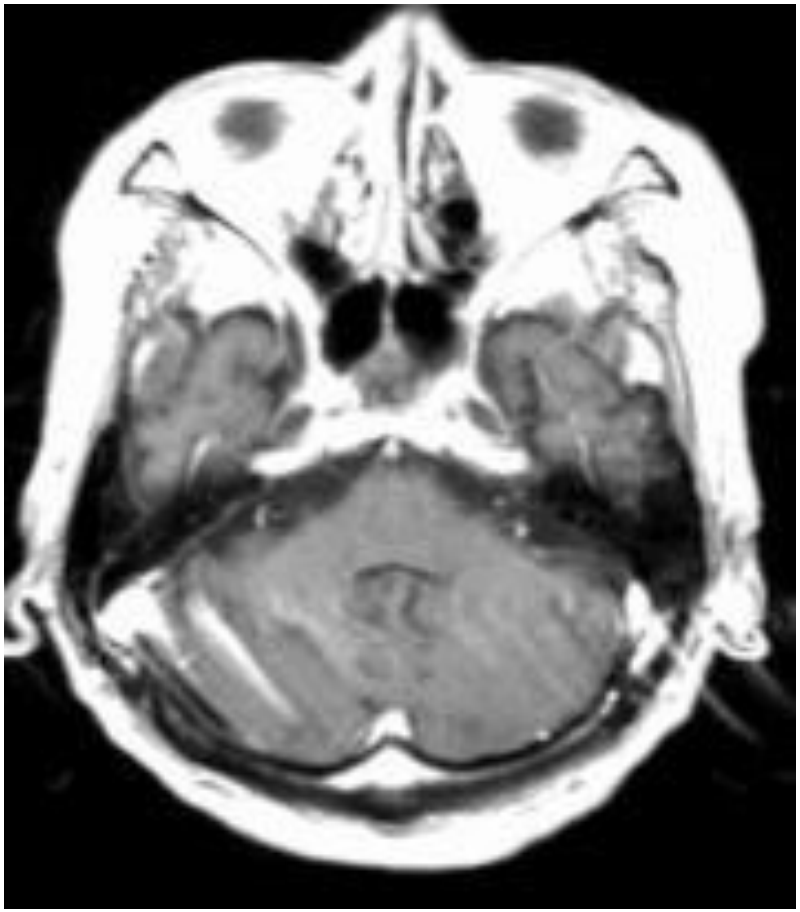
- Respiratory triggering
- Breath hold
- Navigator



Peristalsis Motion Artifacts

Solution for Peristalsis motion artifacts:

- Give an Anti-peristaltic drug (prescribed by referring physician)
- Patient preparation (NPO, Nothing Per Orem)
- Strap the patient tight
- MultiVane



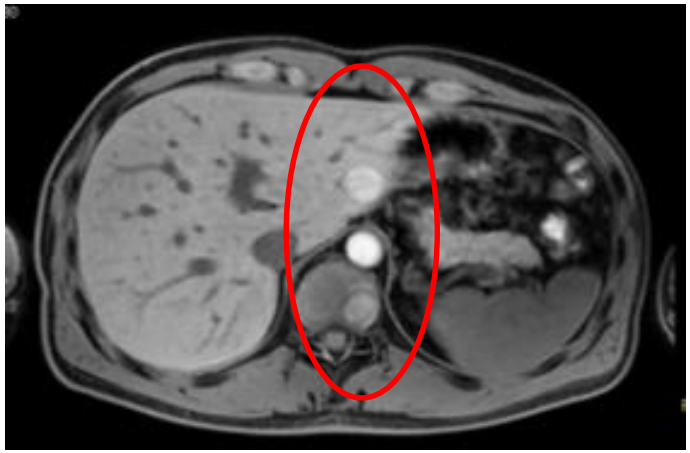
Blood Flow Motion Artifacts

Solution for Blood flow motion artifacts:

- REST
- Flow compensation
- Cardiac synchronization
- Black blood sequences

flow com : no

flow com : yes



CSF Pulsation Motion Artifacts

Solution for CSF pulsation motion artifacts:

- Flow compensation
- Cardiac synchronization
- b-FFE

flow com : no

flow com : yes

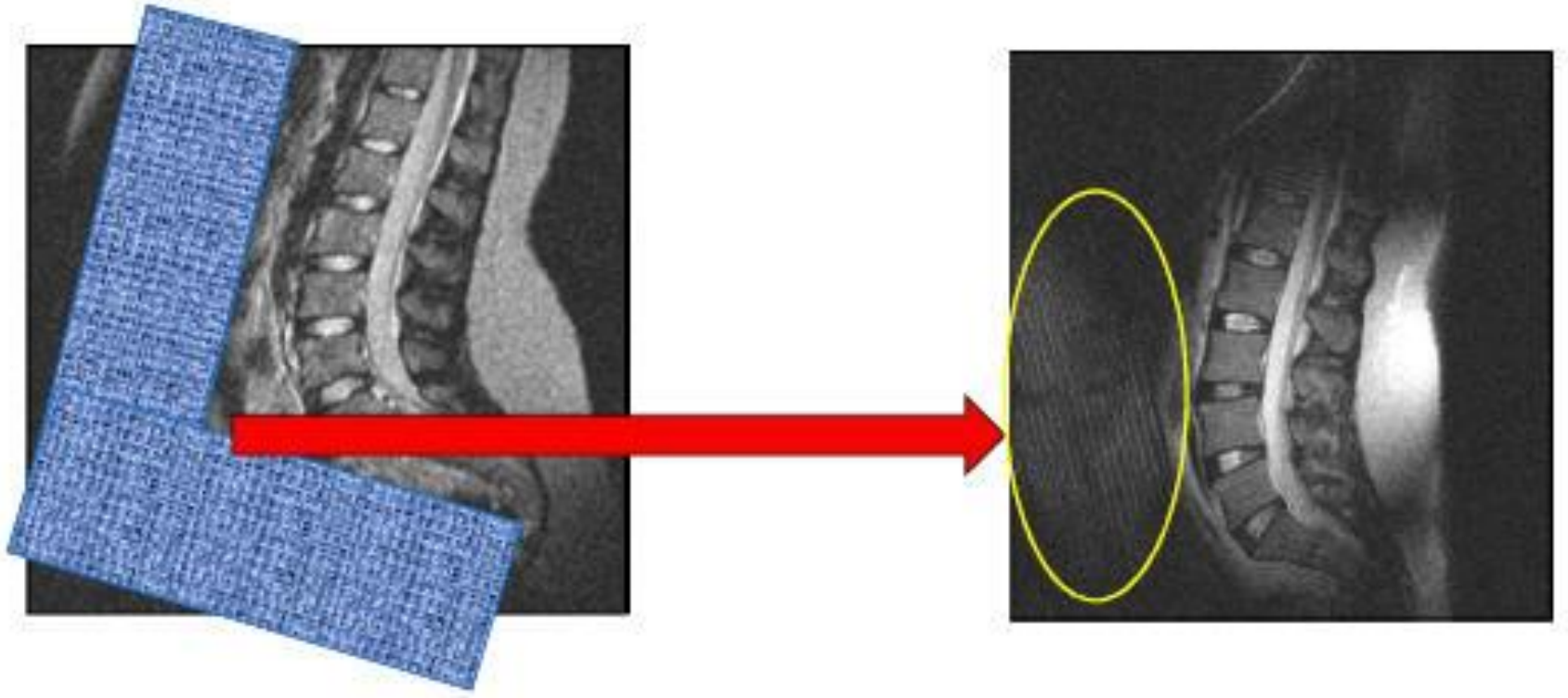
REST Artifact

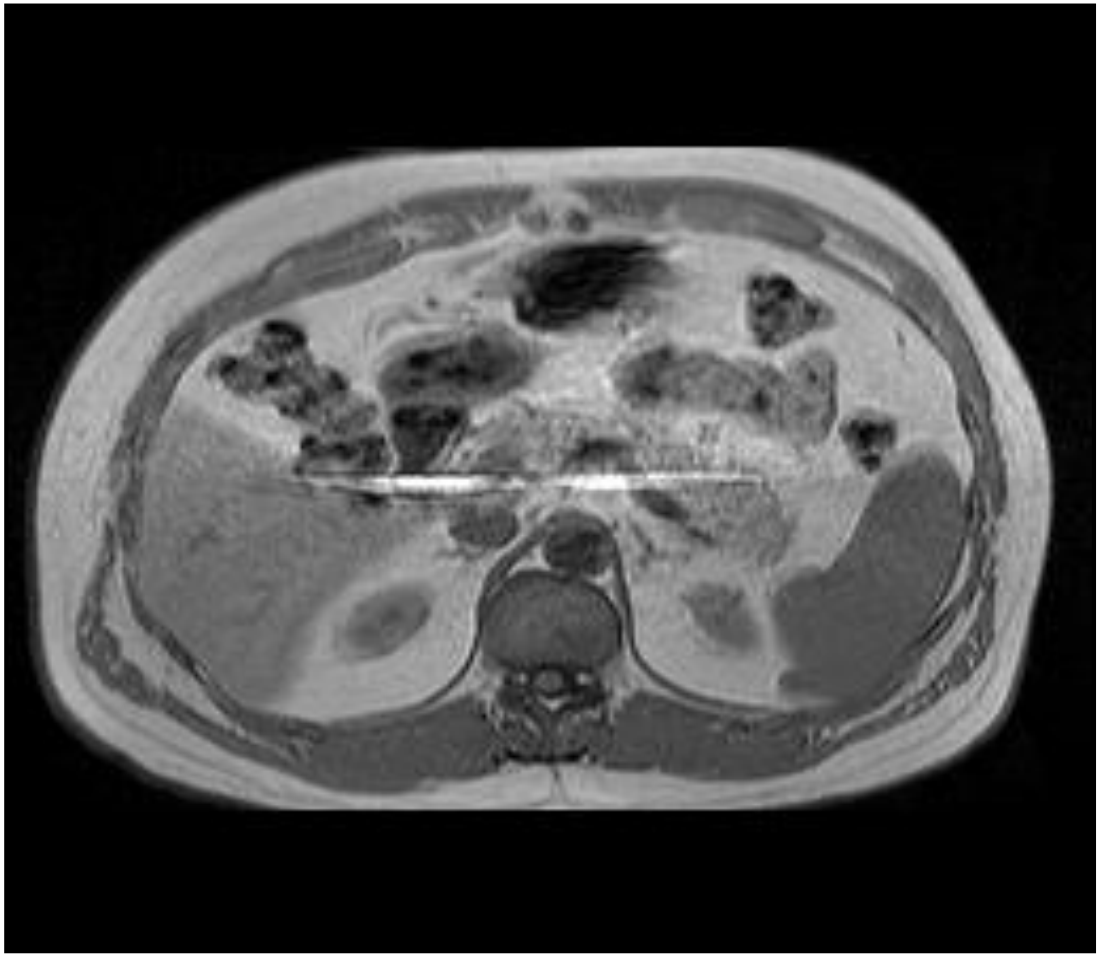
Causes of the REST artifact:

- Two or more REST slabs intersect each other.

Recommendations :

- Apply REST slabs so that they do not overlap.

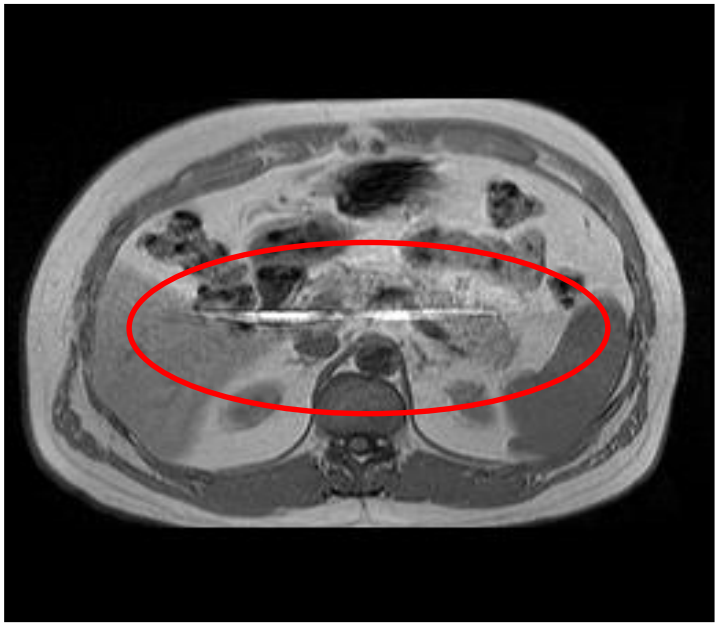


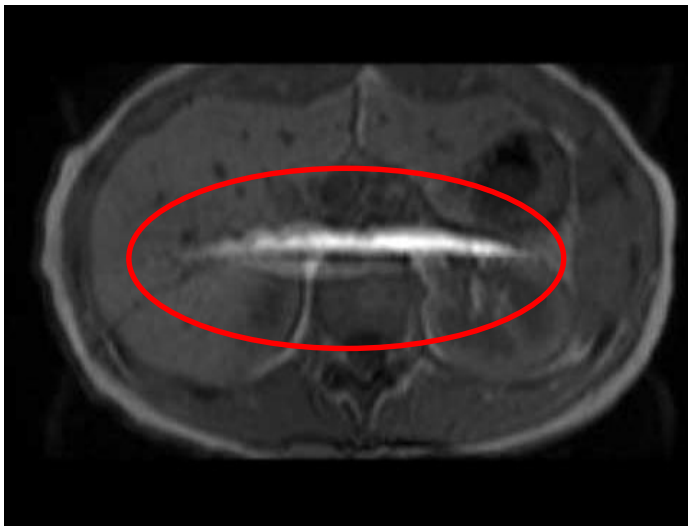


SENSE Artifacts

Causes of SENSE artifact:

- FOV, RFOV or 3D volume planned too small on the anatomy

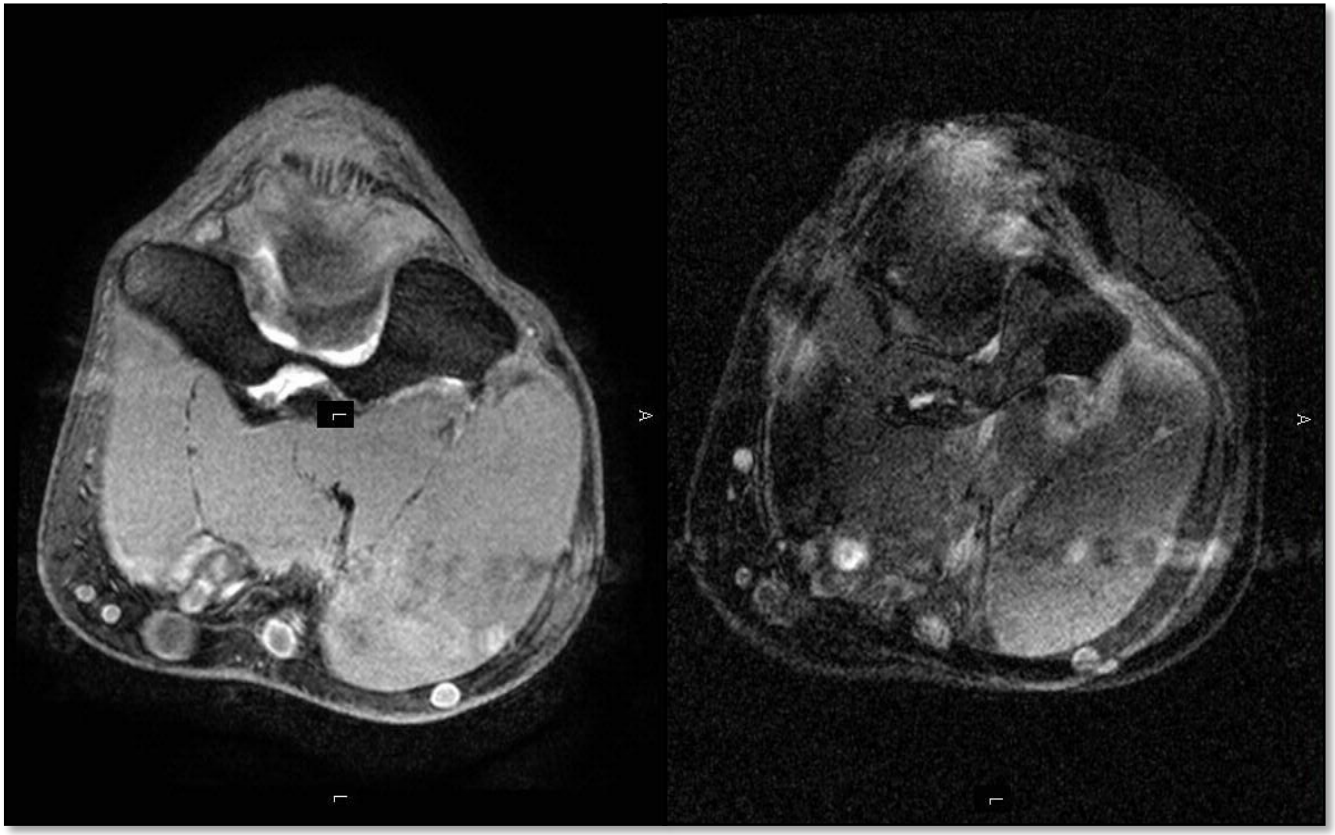




SENSE Artifact

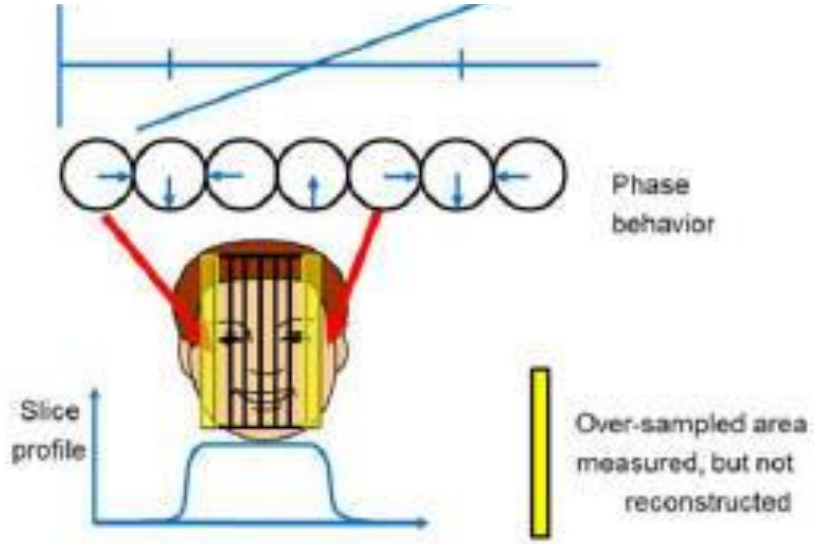
Recommendations :

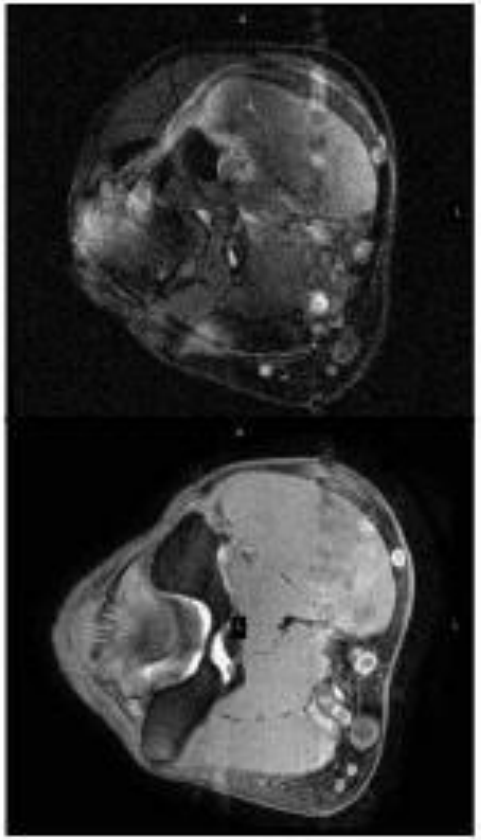
- Enlarge the FOV, RFOV or 3D
- Increase inplane oversampling
- Increase slice oversampling or increase slice coverage
- Reduce SENSE factor
- Make sure the pre scans are repeated if:
  - The coil or patient moved.
  - If plugs are removed and plugged in again.

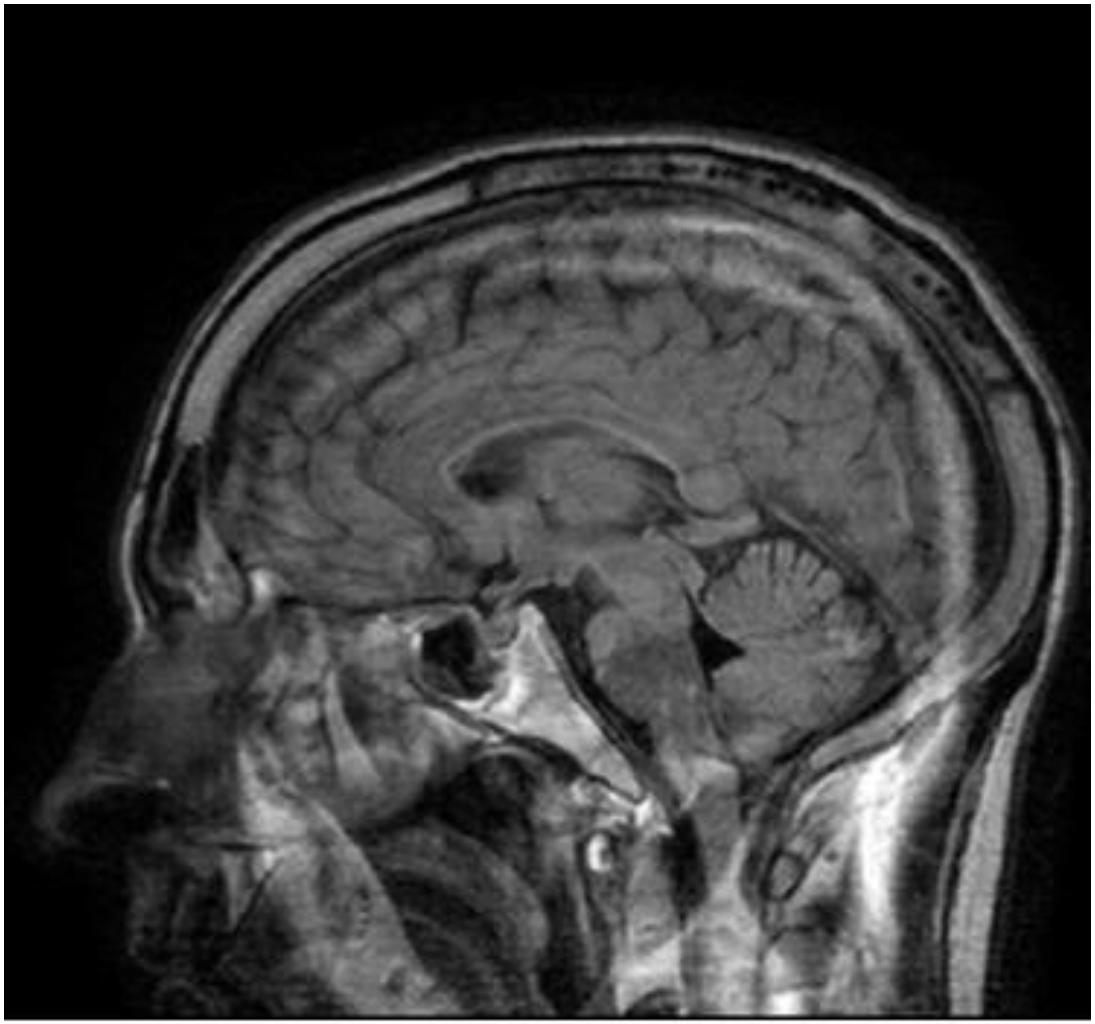

L
A
L
A
L

Foldover in Slice Selection direction (3D)

- Slice direction acts as additional phase encoding direction.
- Can be controlled by use of Slice Oversample factor





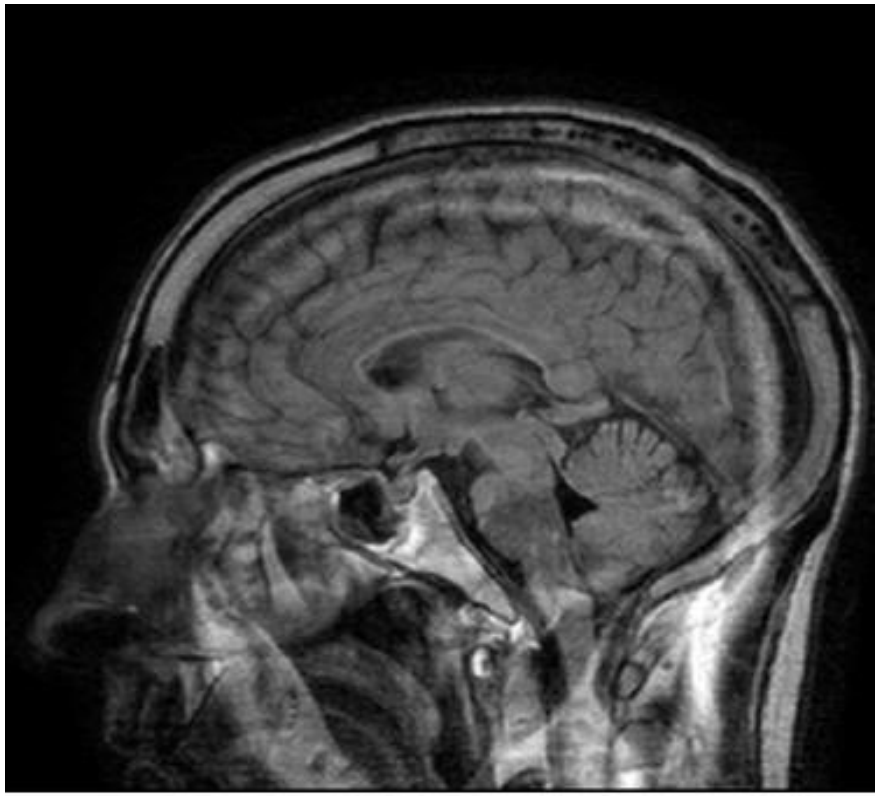


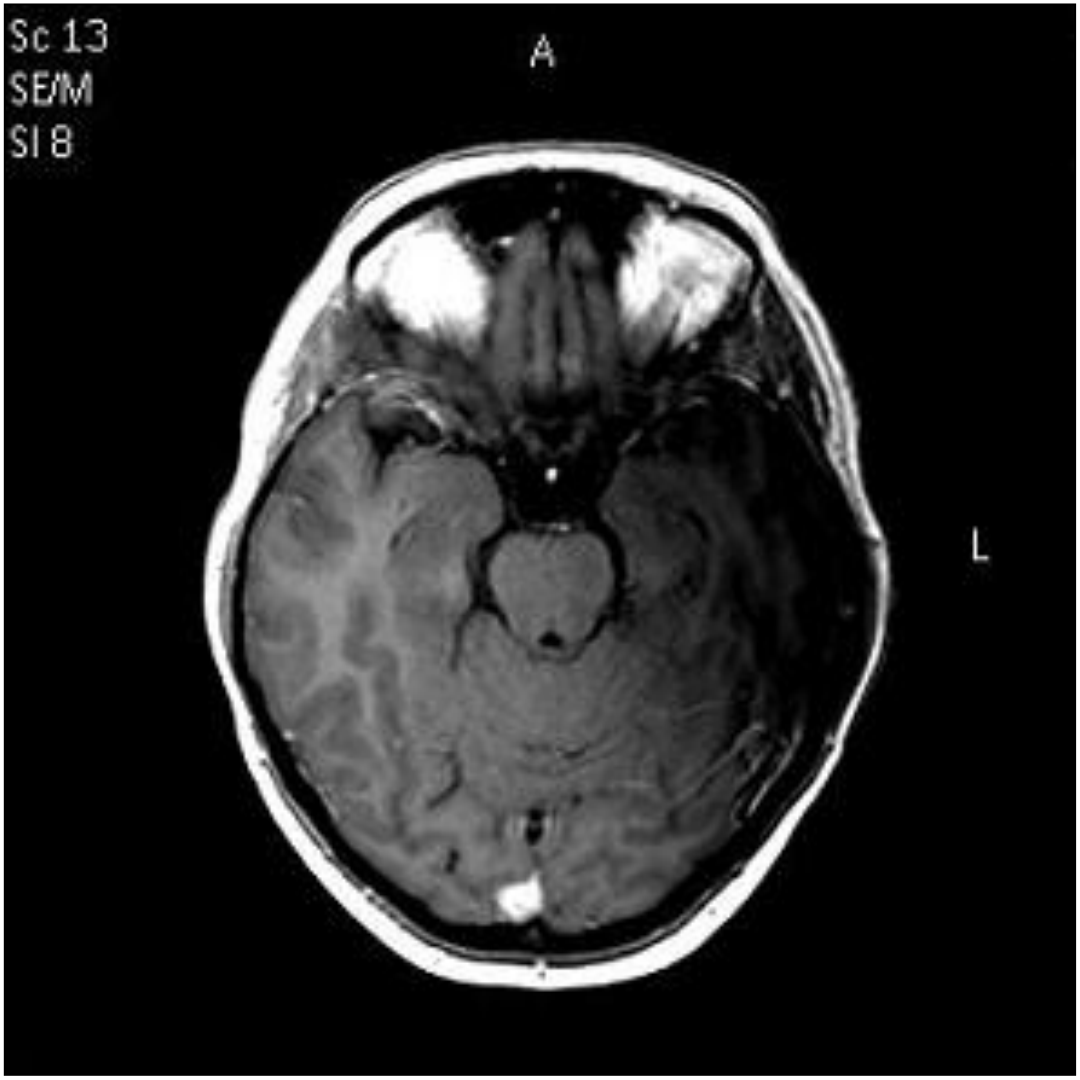
SENSE foldover in slice selection direction

SENSE applied in SS direction → foldover occurs in central slices of the 3D volume.

Recommendations :

- Decrease SENSE factor
- Increase oversampling
- Increase SS coverage (increase slice thickness, increase number of slices)

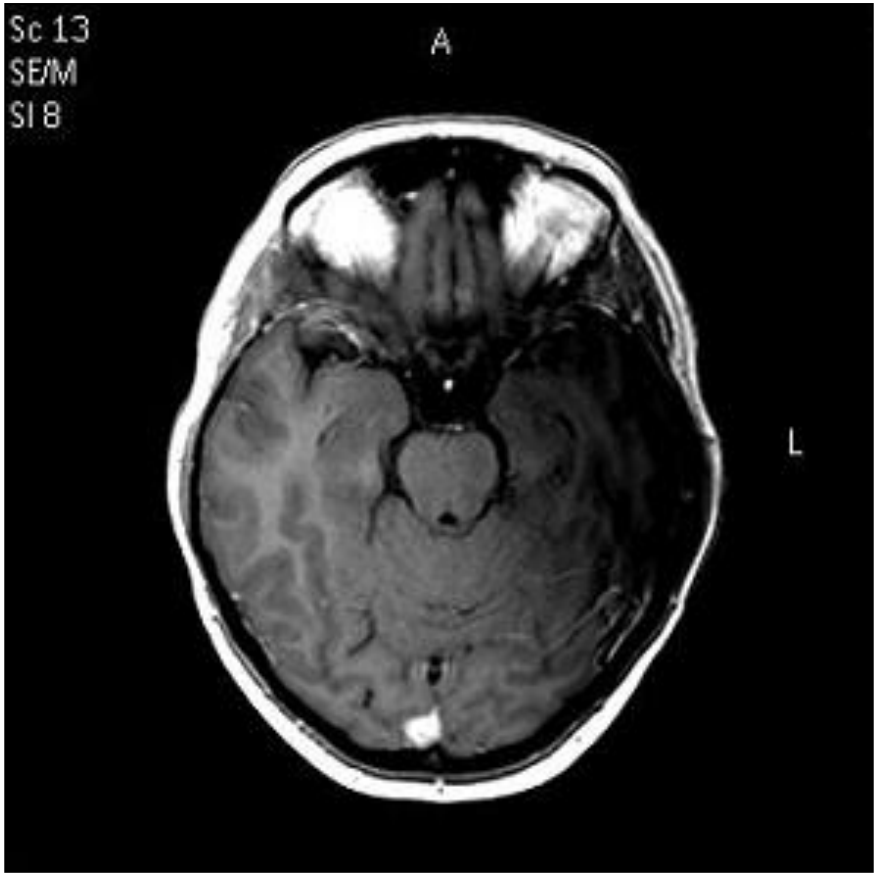



Sc 13
SE/M
SI 8
A
L

Coil signal decrease

Recommendations :

- Reposition the coil/patient.
- Make sure coil parts are latched and coil is correctly plugged in.



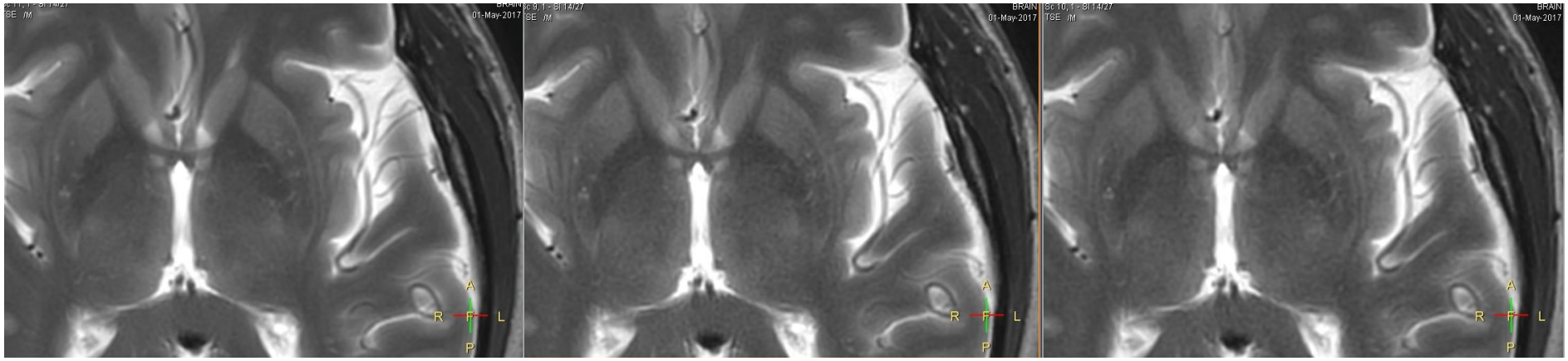

A
R
L
P


R

Low MultiVane percentage

- Causes streaking artifacts

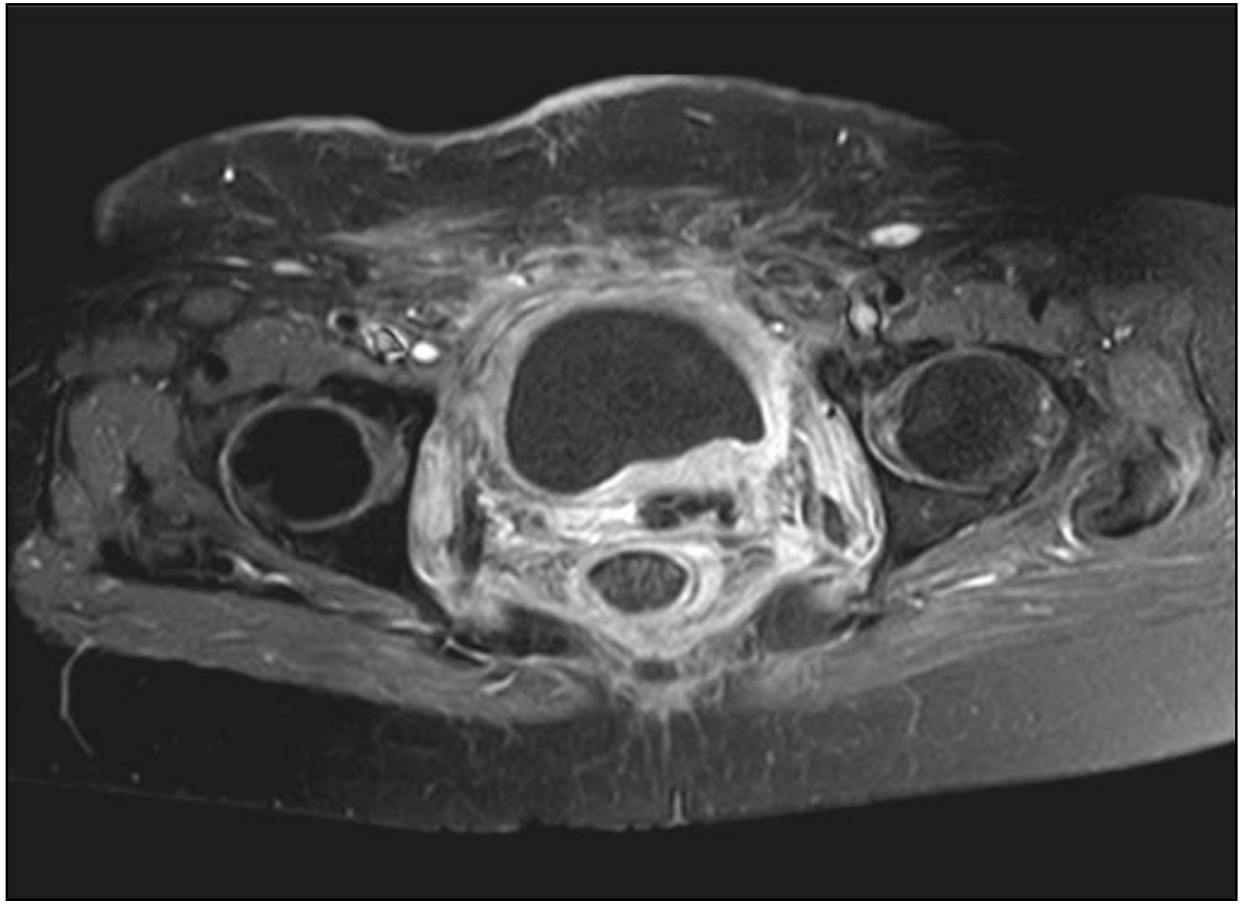
MultiVane percentage increases SNR



300%

160%

100%



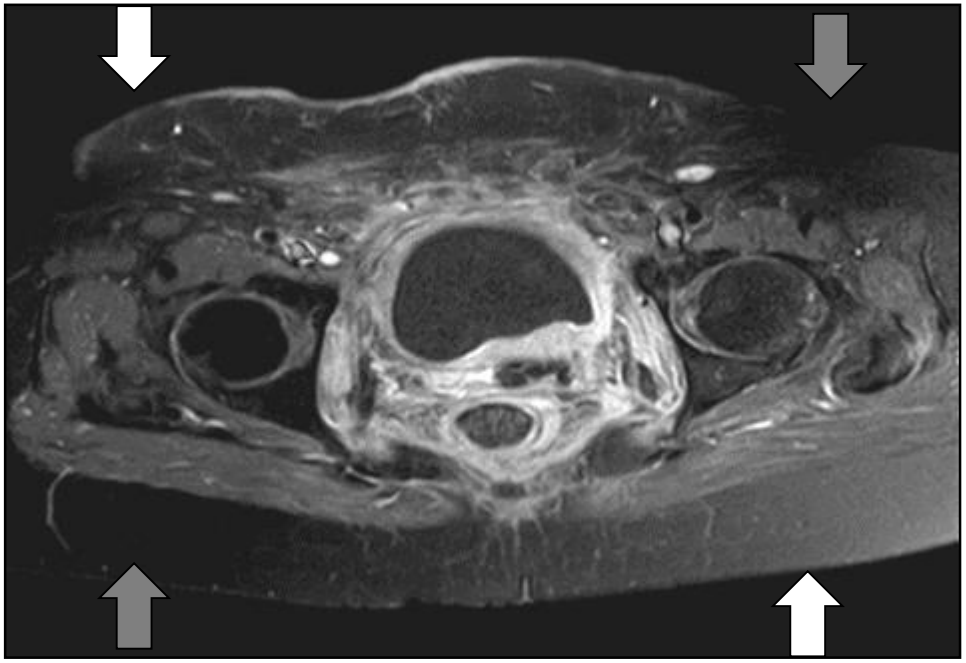
Quadrupole Effect

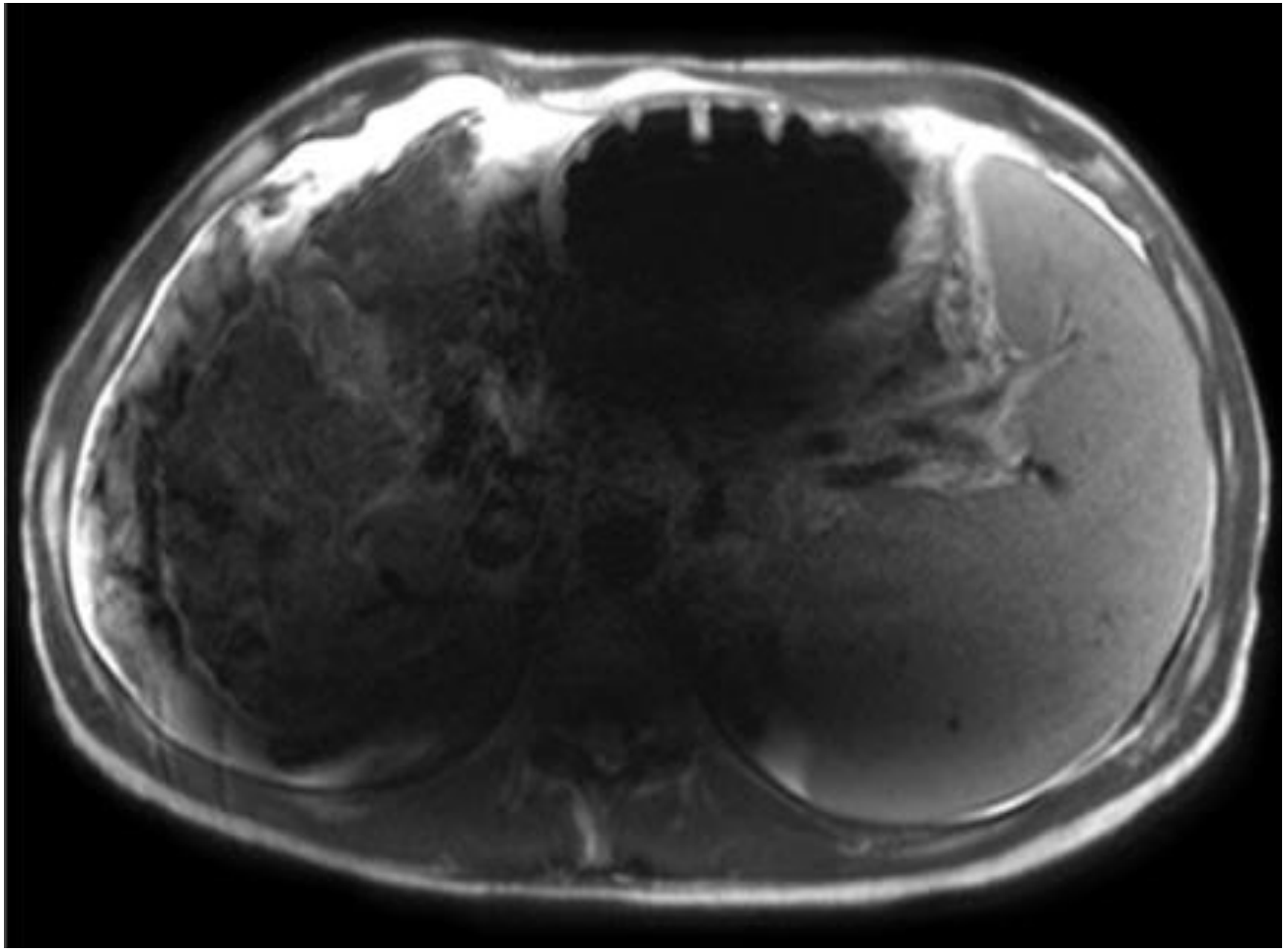
Causes of Quadrupole:

- B1 disturbance from L to R and A to P caused by standing RF waves in the patient.

Recommendations :

- Select STIR or SPAIR instead of SPIR.

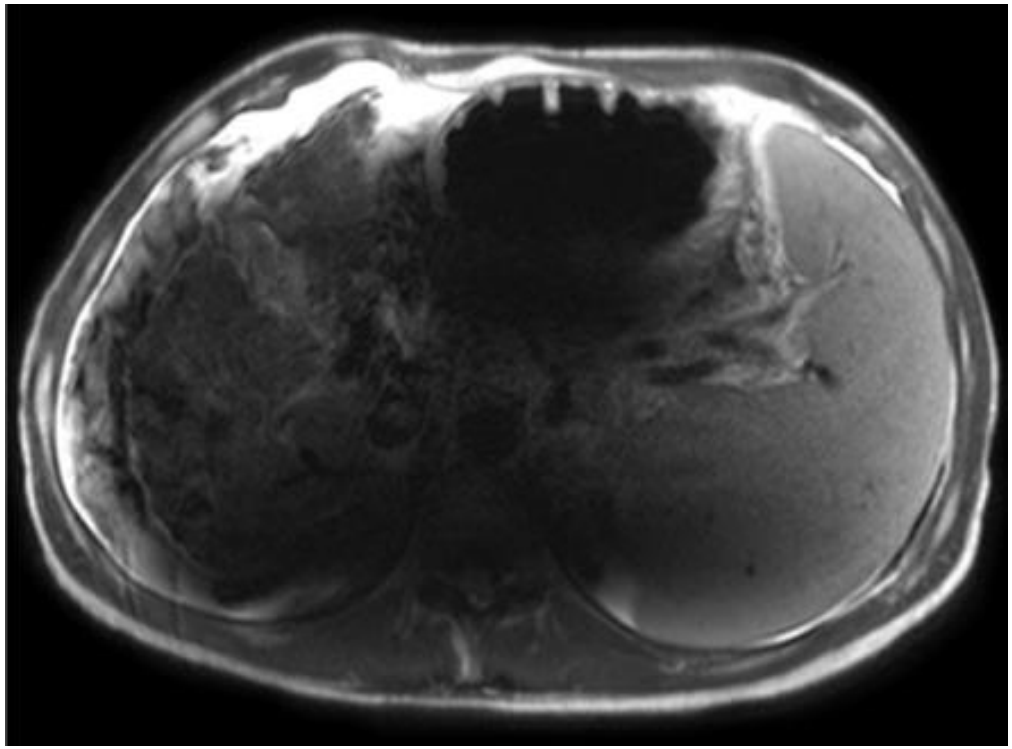


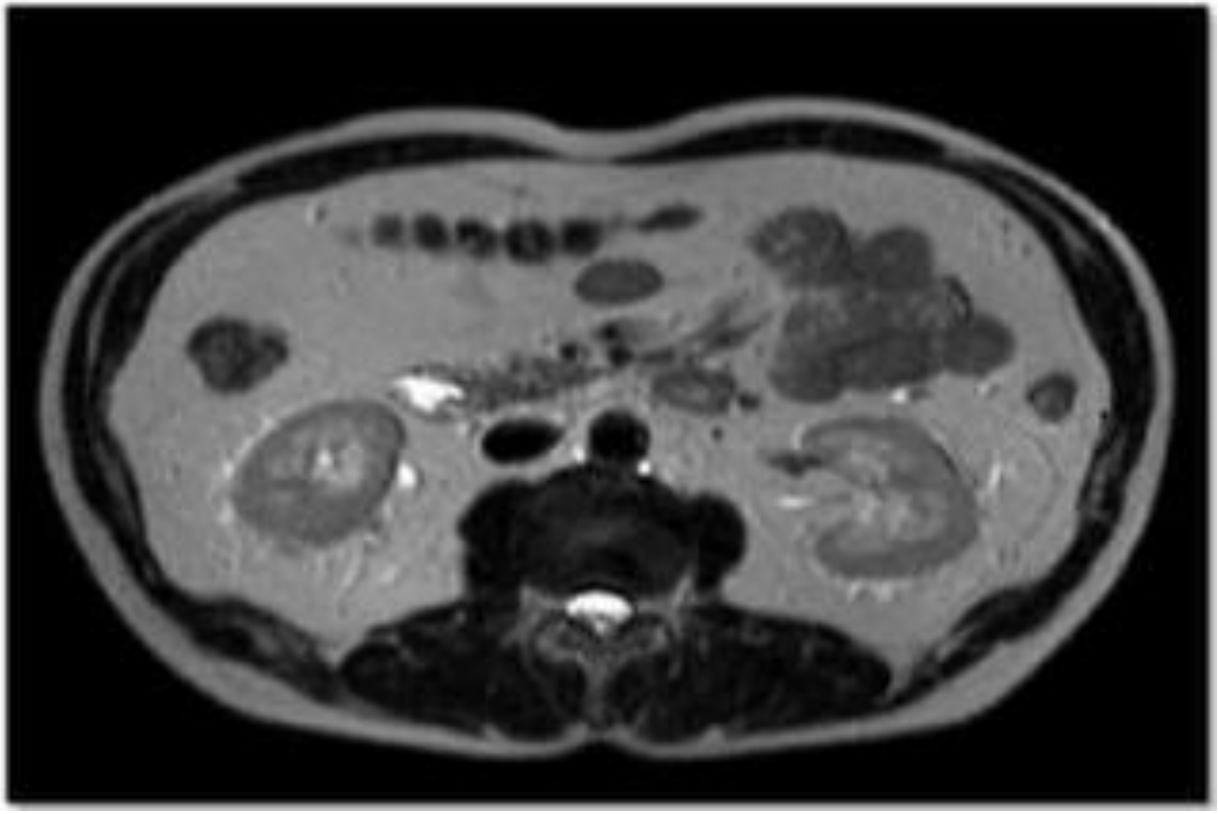


B1 Inhomogeneity

Recommendations to get a more homogeneous image:

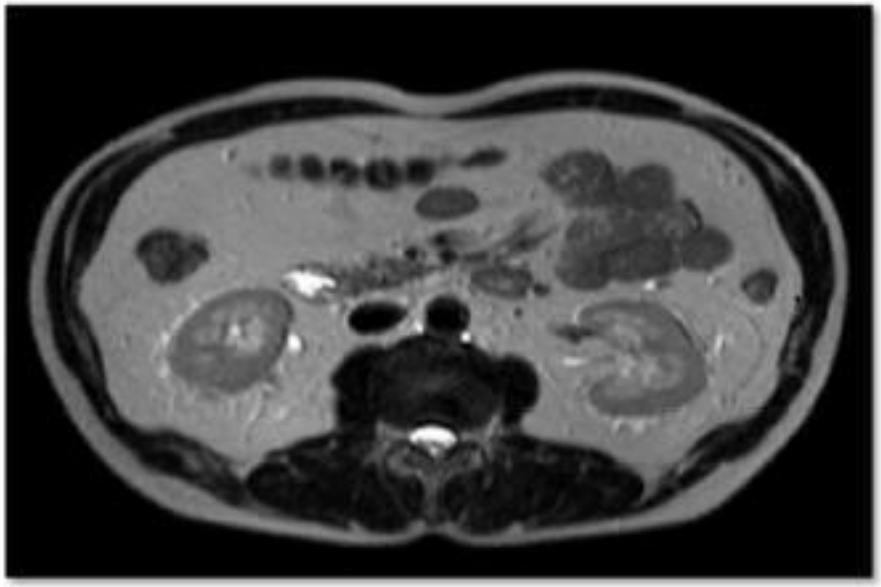
- CLEAR algorithm
- Body tuned CLEAR algorithm





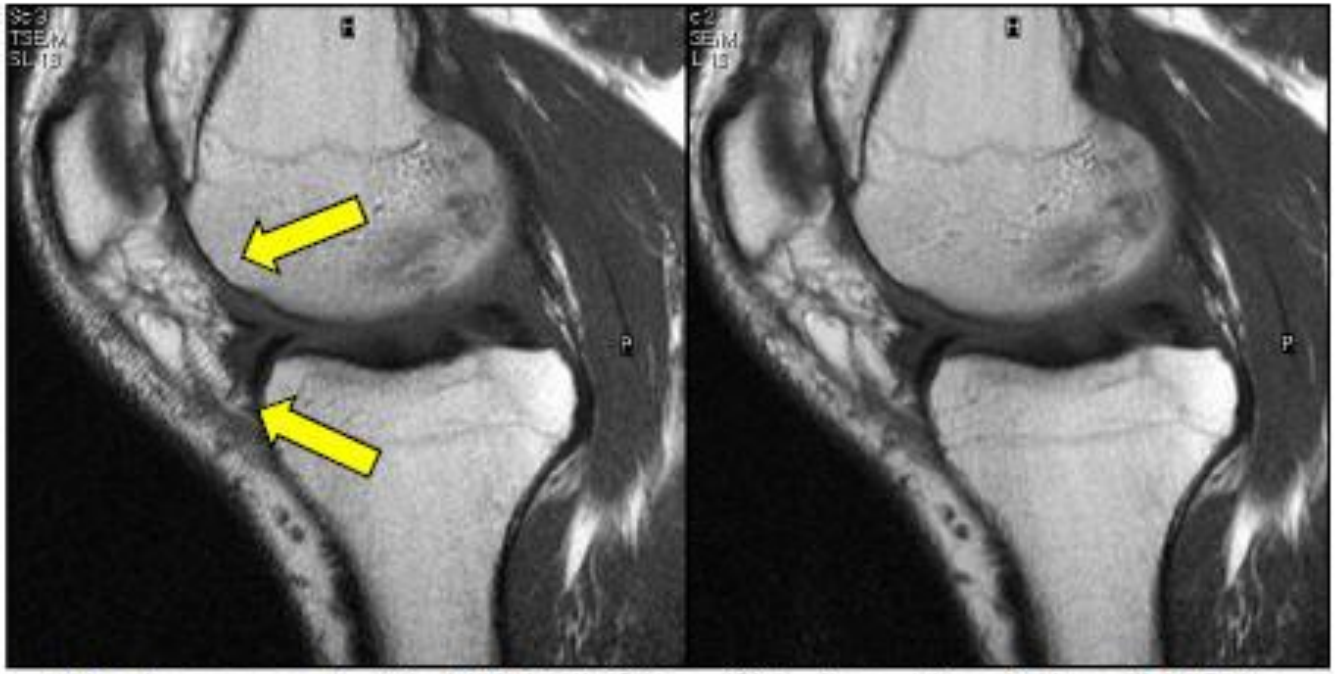
Blur artifact (high turbo factor)

- Tends to happen when an operator attempts to increase the spatial resolution of a single shot scan.




P

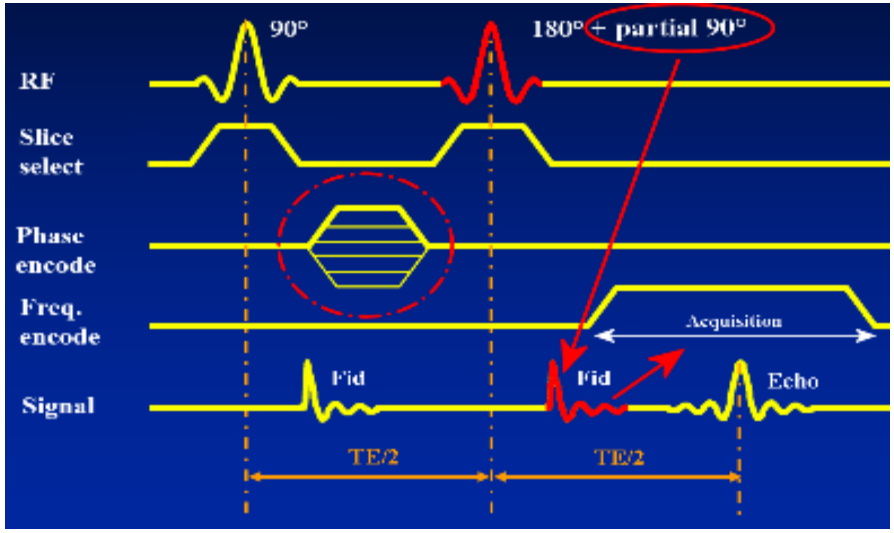
FID artifact (or stimulated echoes)

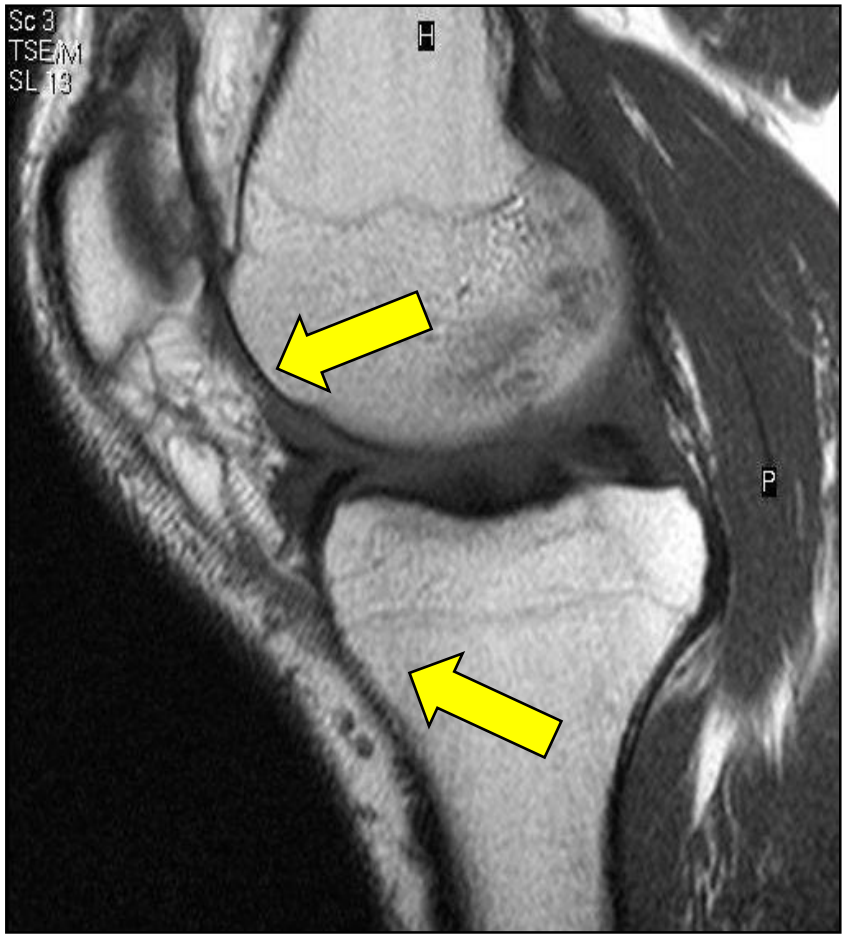


Most apparent with T1/PD TSE Solution: Use 2 “real” NSA’s

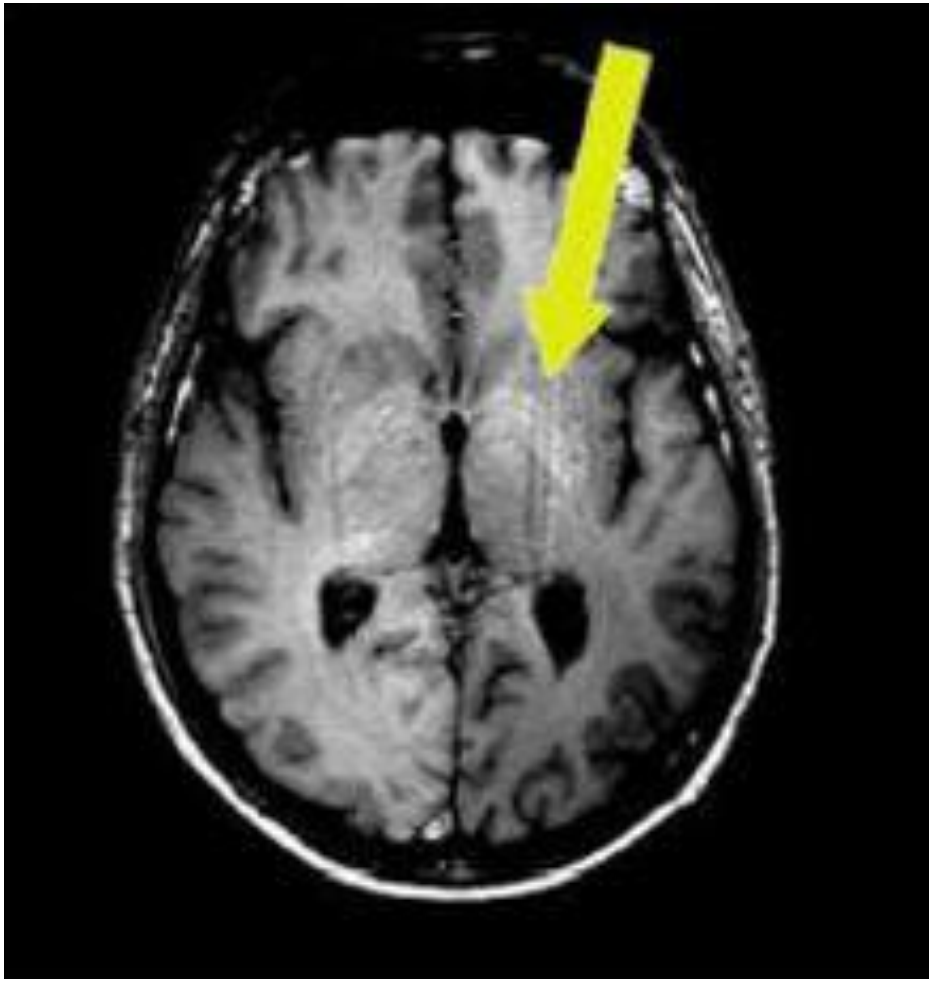
FID artifact (or stimulated echoes):

- Can be reduced by:
  - **NSA** minimum of **2**
  - **Flow compensation** is set to **yes**
  - **FID reduction** (gradient crusher) set to **strong**



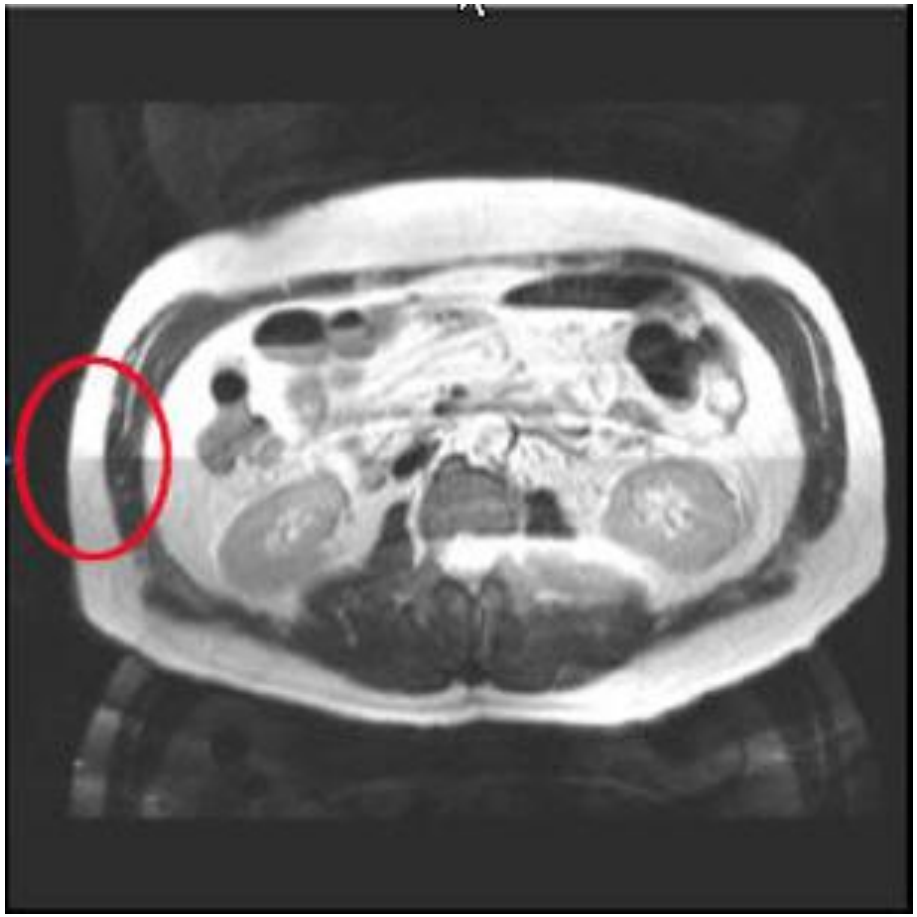


Do not combine flow compensation and FID reduction.
Only use flow compensation if FID reduction parameter is not available.
(Because flow compensation will reduce SNR)



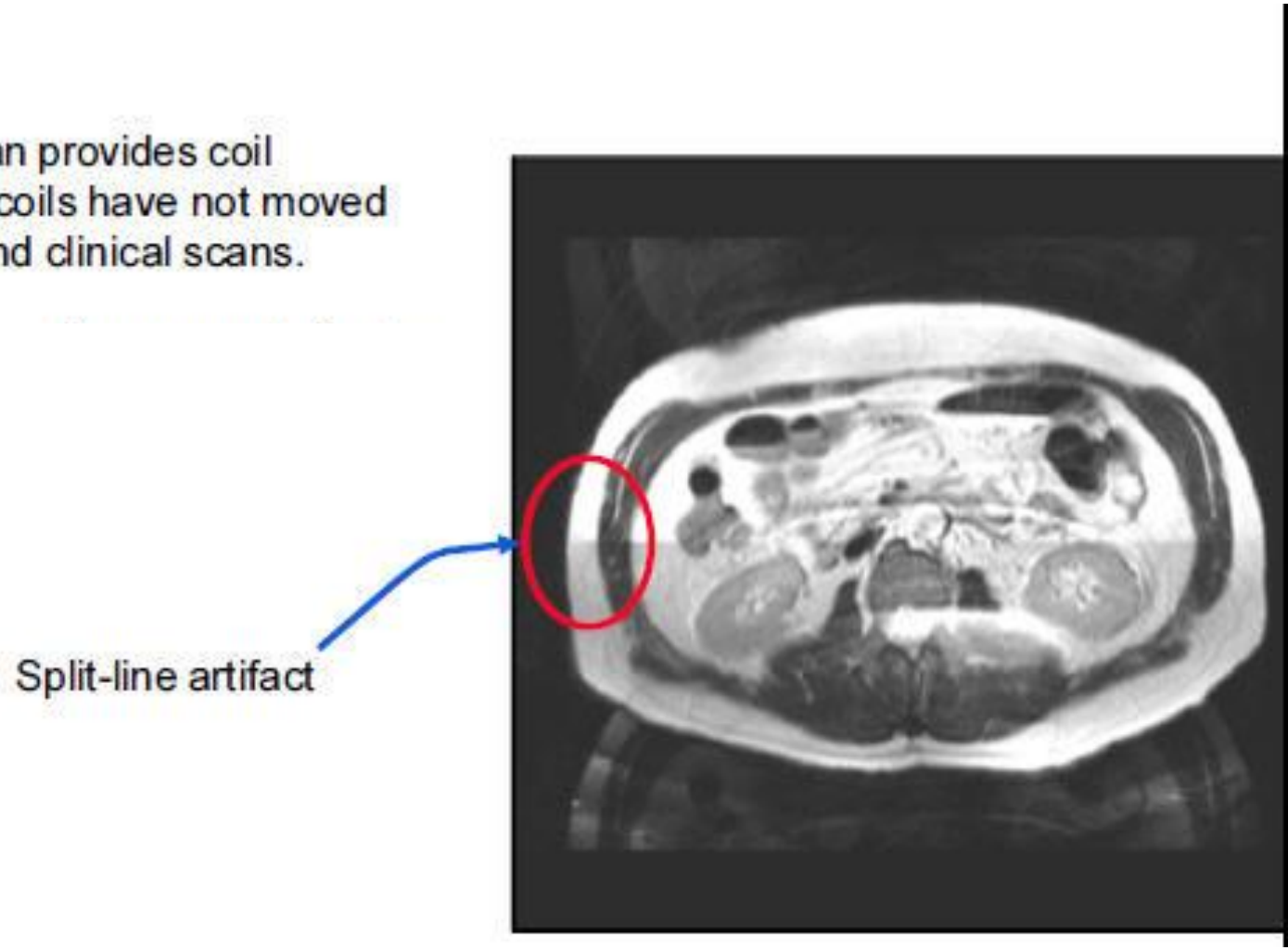
Proton signal in passive headset

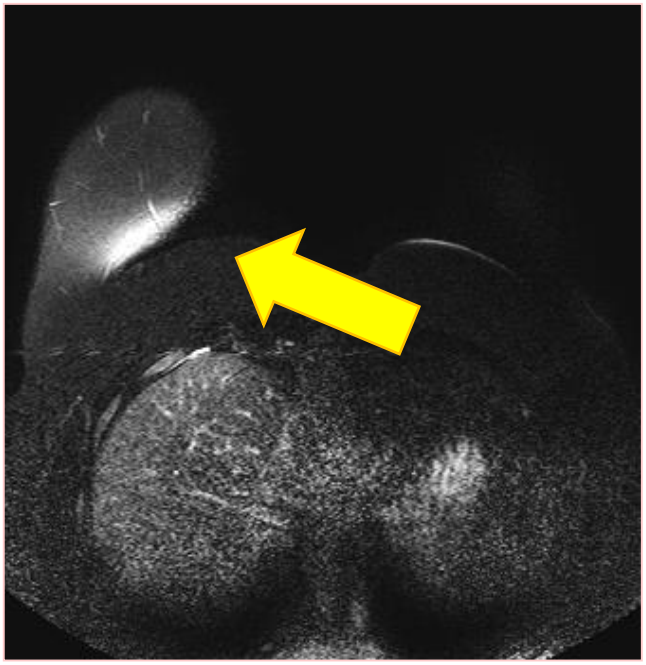
- Advice has always been to use only the patient headset that connects to system.
- Can fold into brain when SENSE is applied.



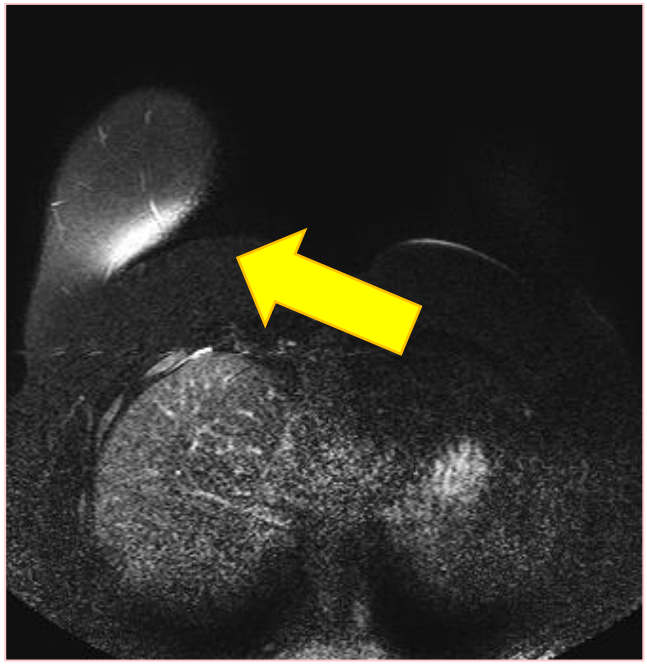
Coil movement

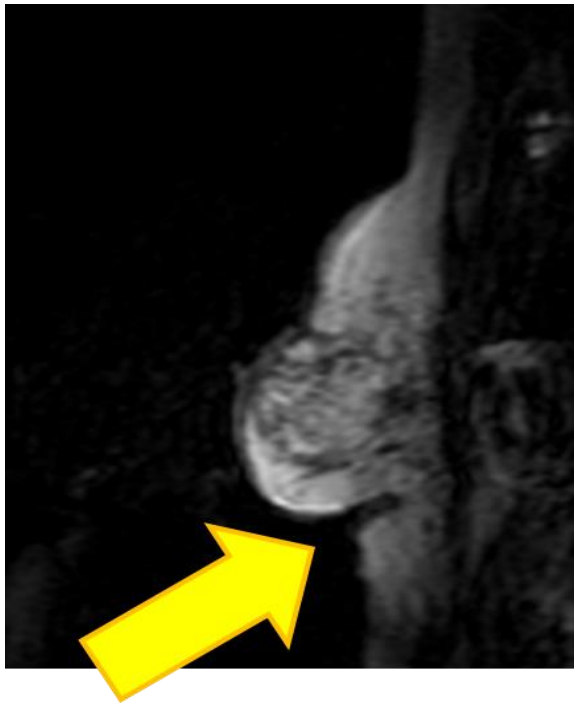
The reference-scan provides coil sensitivities if the coils have not moved between the ref and clinical scans.

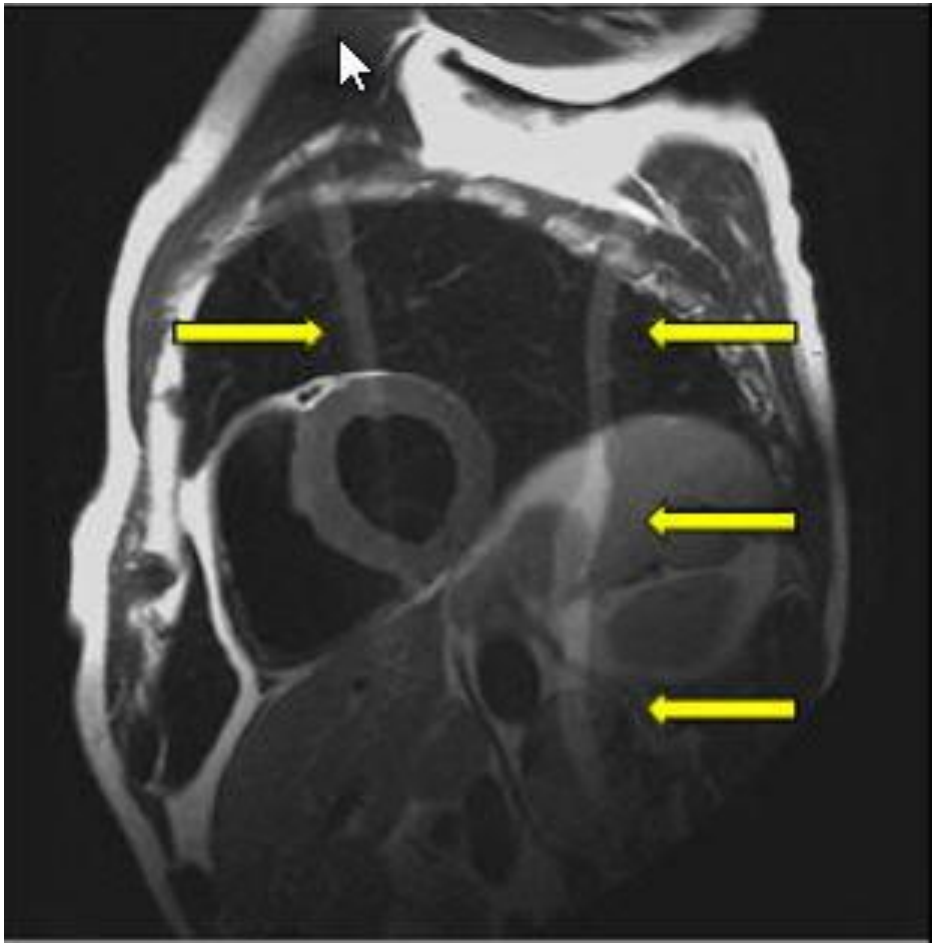




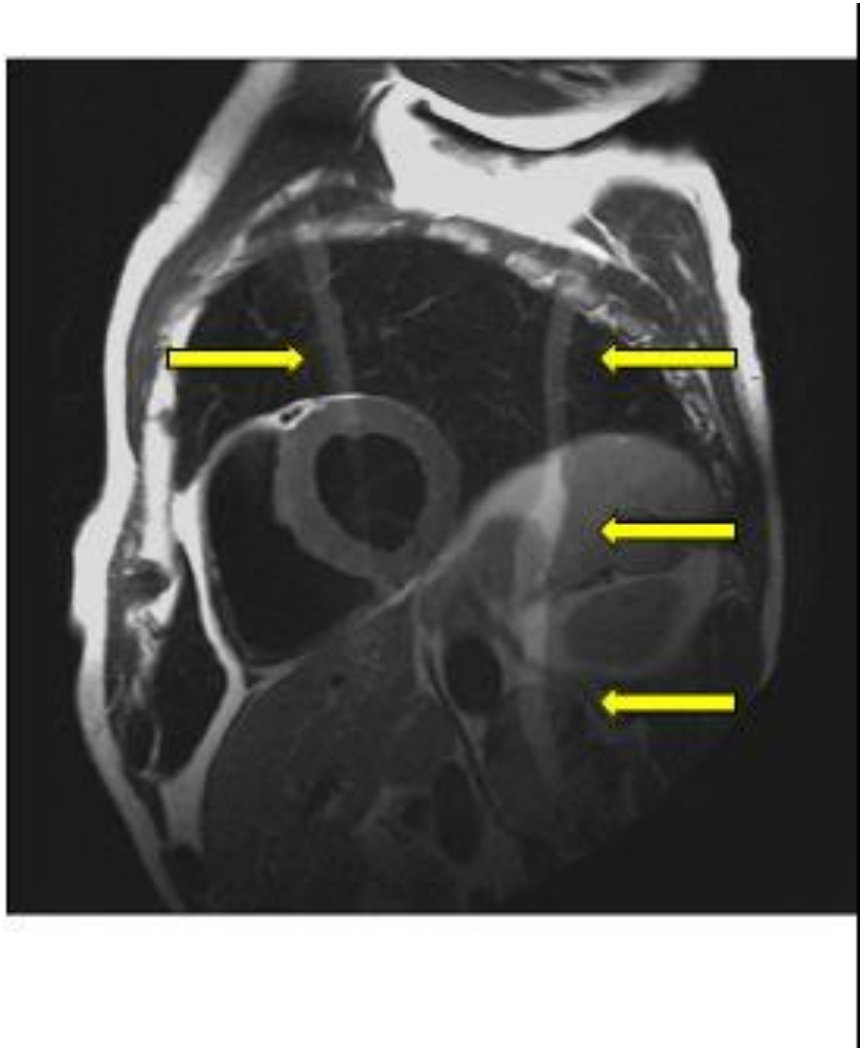
Breast positioned with a fold





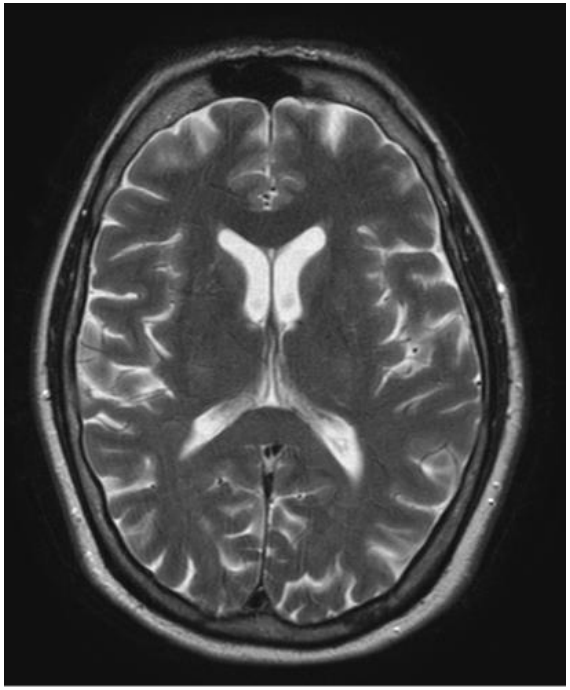


SENSE artifact

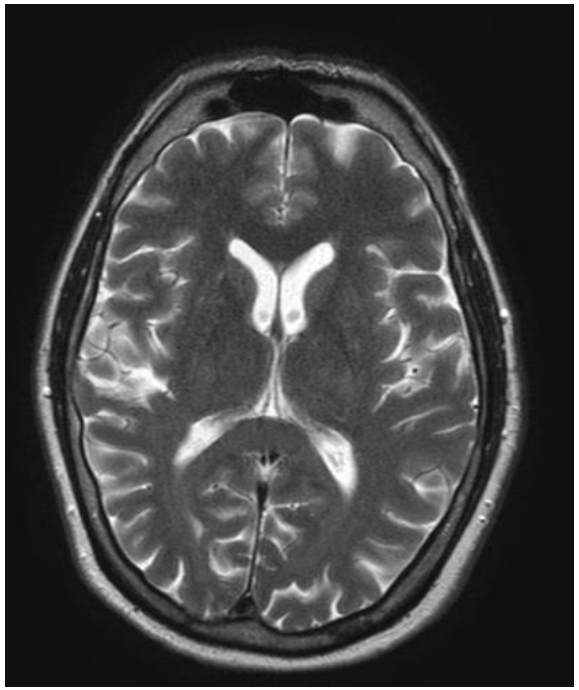


SENSE adjustment

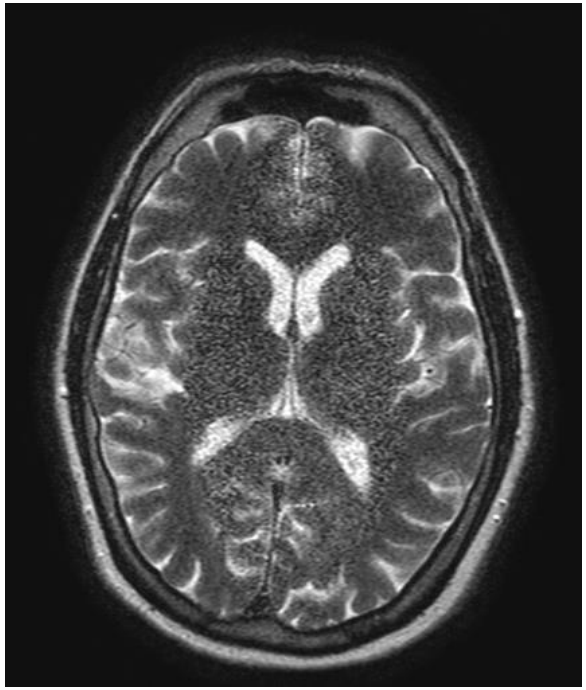
If SENSE increases → SNR decreases → a central noise band appears in the image



SENSE = 1



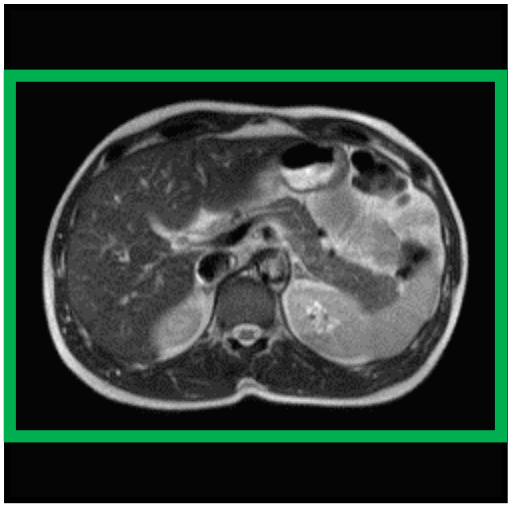
SENSE = 2



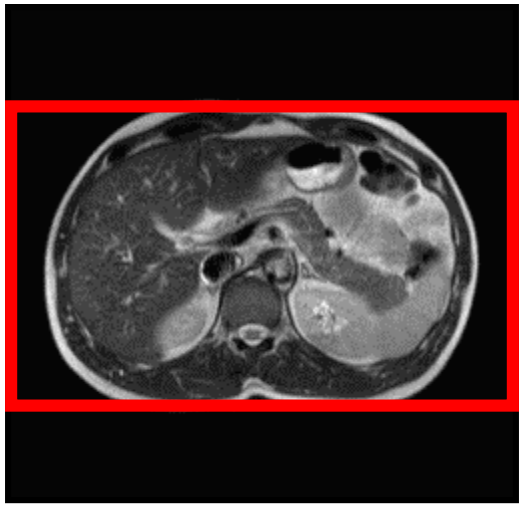
SENSE = 4

Slices positioning with SENSE

- All anatomy needs to be in the FOV if SENSE is applied

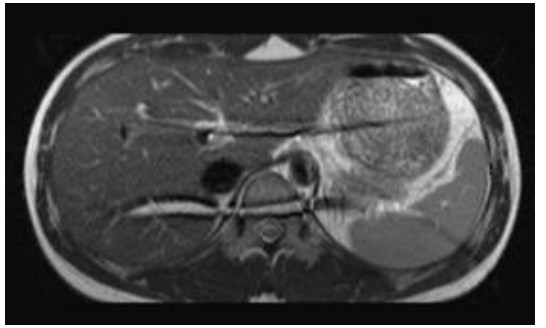


Correct planning

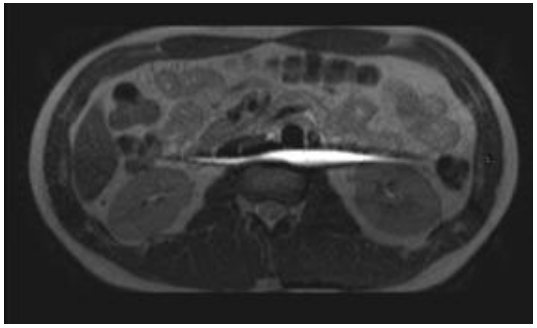


Planning too tight

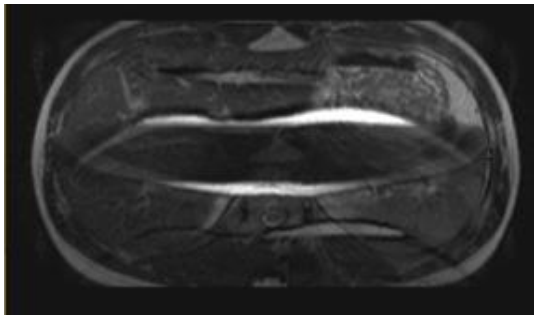
SENSE 1.5



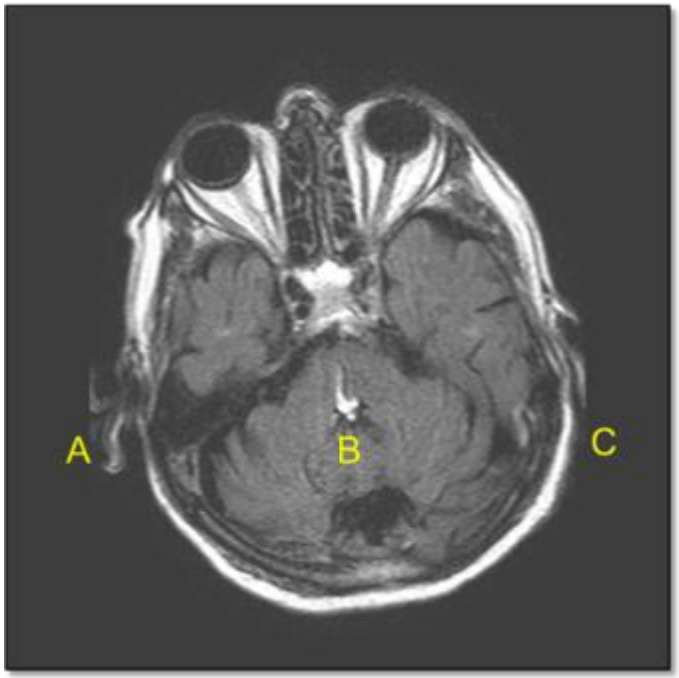
SENSE 2.0

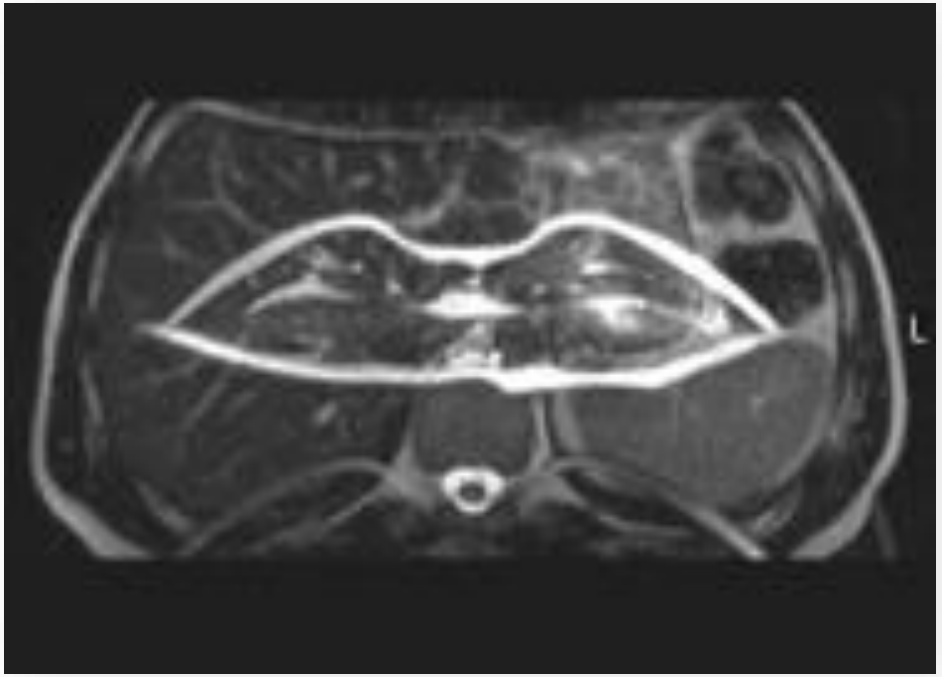


SENSE 2.5



Other examples of FOV too tight

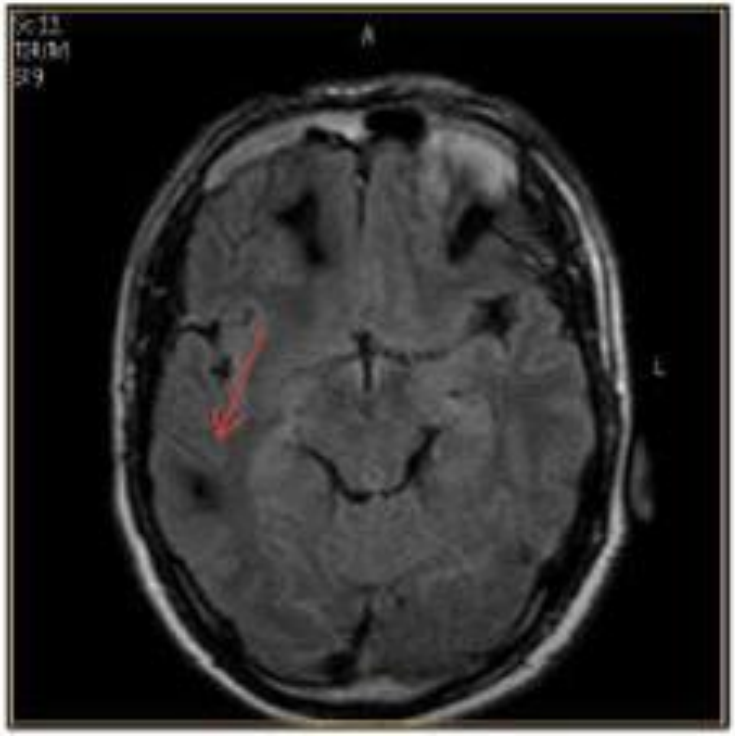




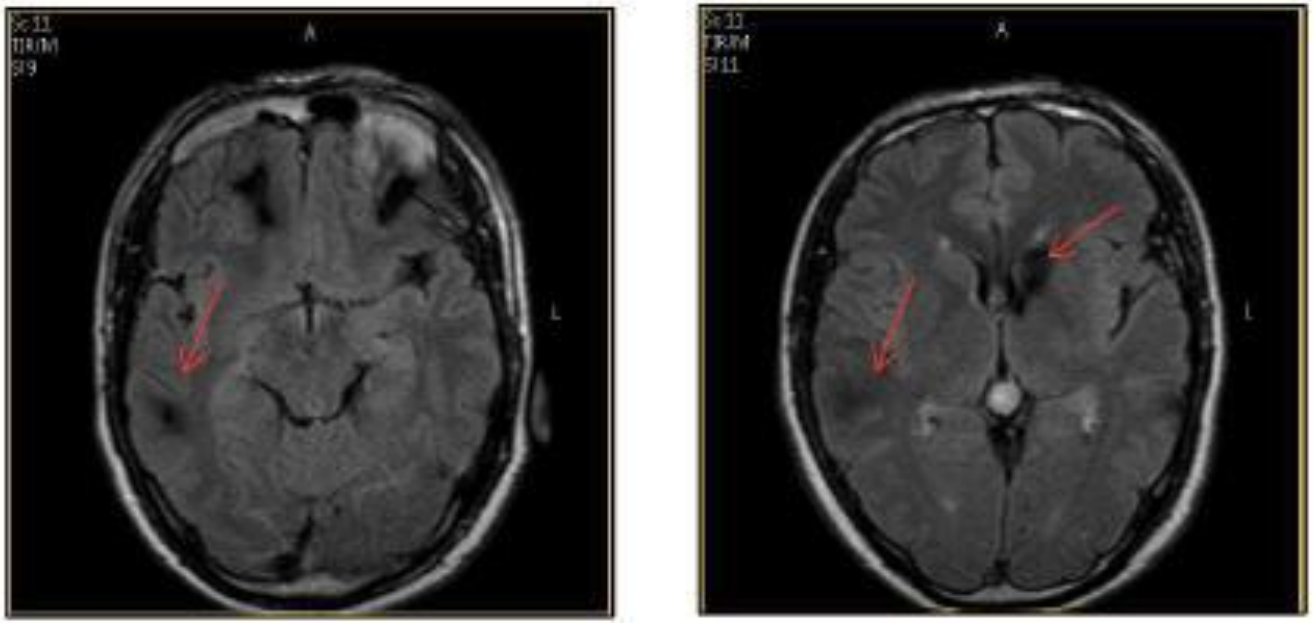
A,B and C signals at the same location

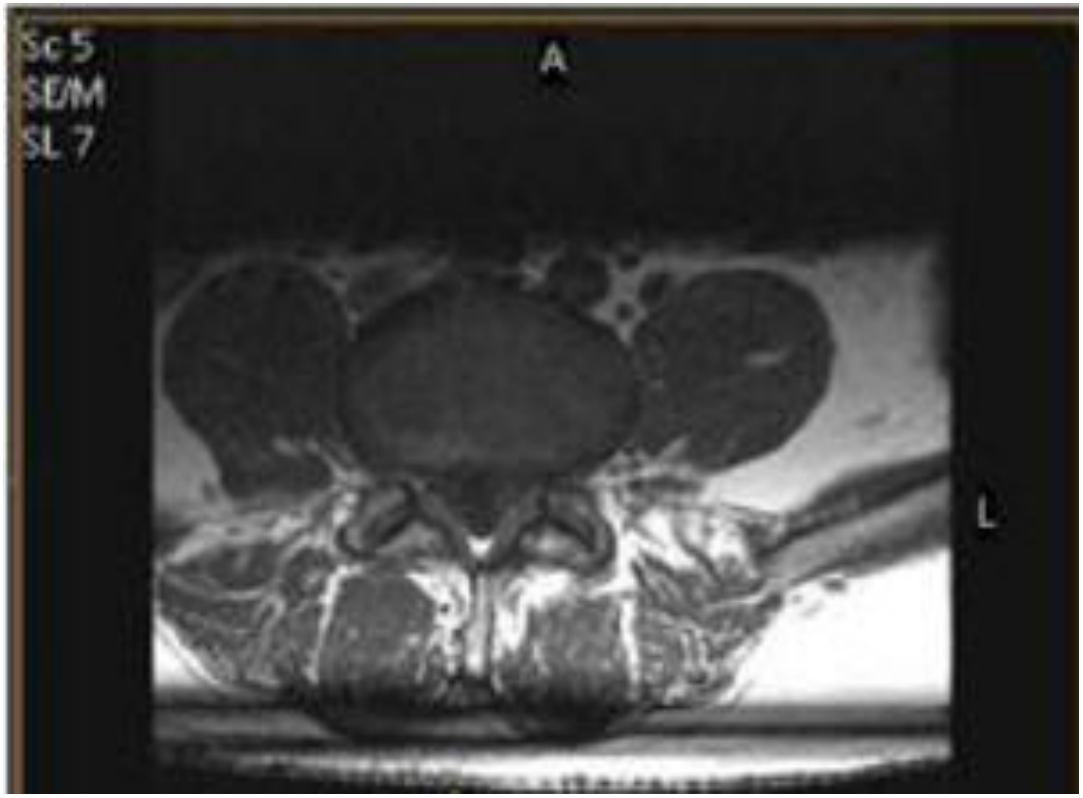
To prevent SENSE artifacts:

- SENSE reduction factor ≤ the number of elements
- Avoid patient movement between reference scan and imaging
- Avoid coil displacement between reference scan and imaging
- Cover the anatomy in phase direction
- In 3D, cover the anatomy in slice direction



Movement during acquisition of the Refscan

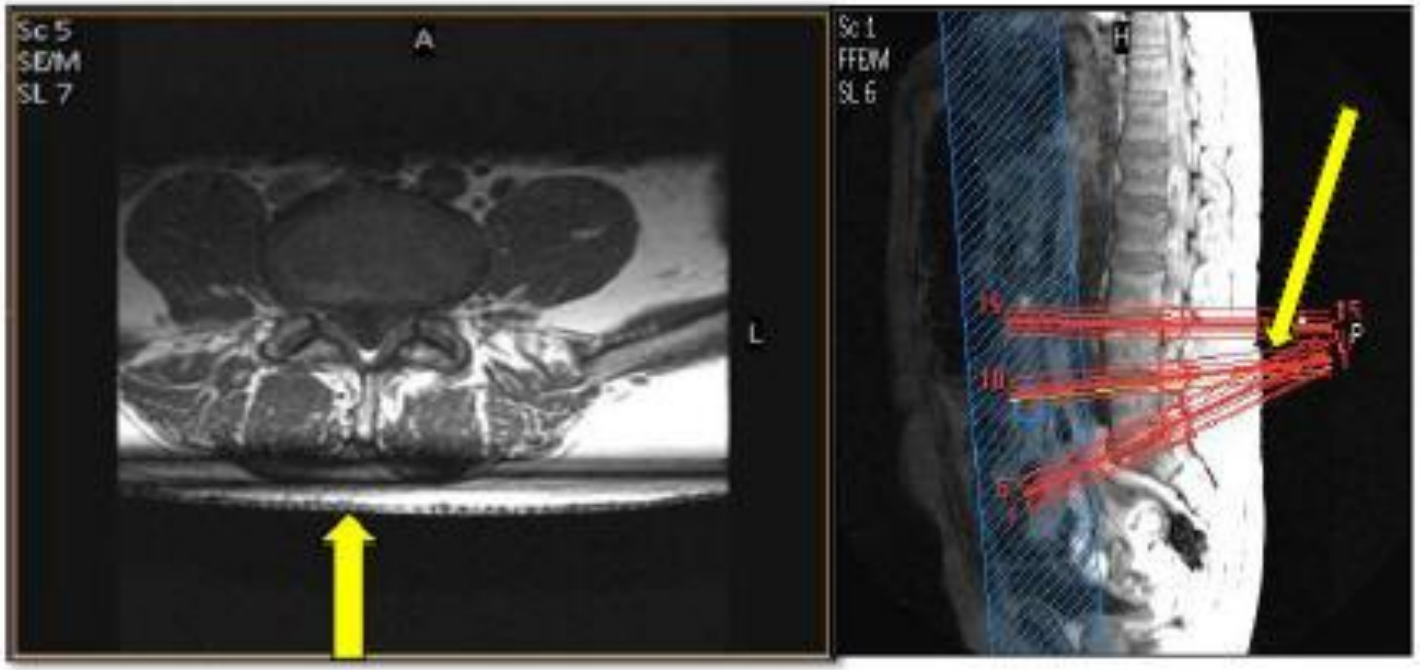



Sc 5
SE/M
SL 7
A
L

Cross-talk artifact (multi-stack sequences)

Can be prevented by setting scan parameter **stacks as packages** to yes.

Note: This will increase scan time



Hardware

Hardware issues can show up in many ways:

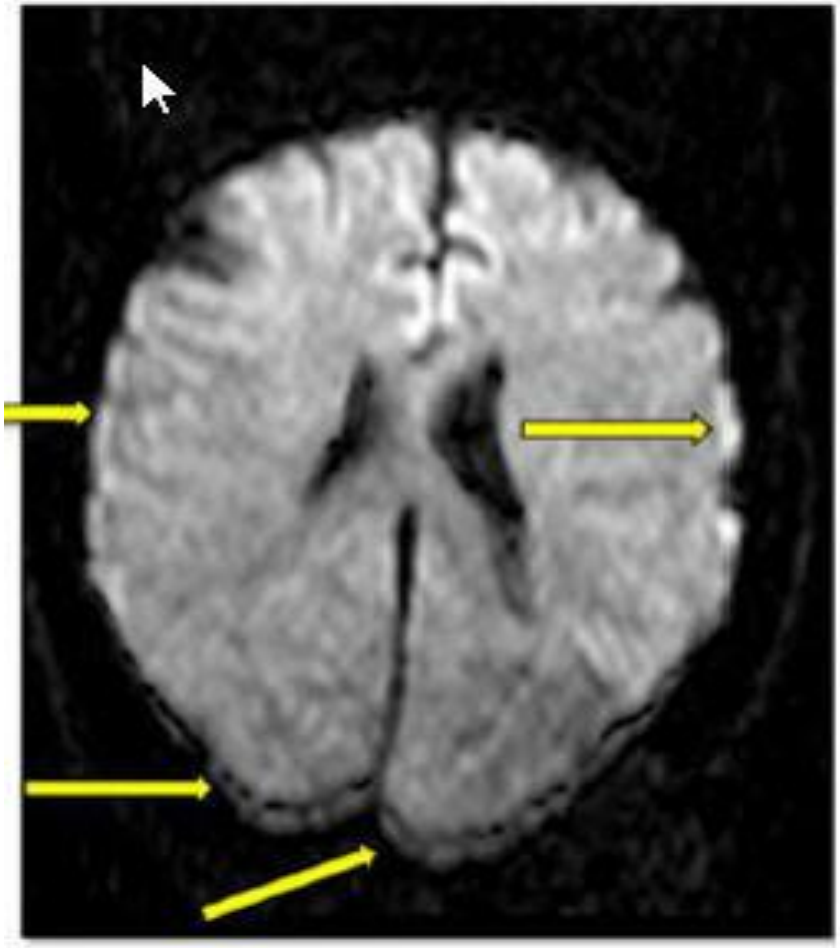
- Dots
- Lines
- Distortions
- Blurring
- Ghosting
- Bands
- Noise (localized or general)
- Patterns (for example “corduroy”)
- Dark spots

If the artifact:

- Shows as straight lines

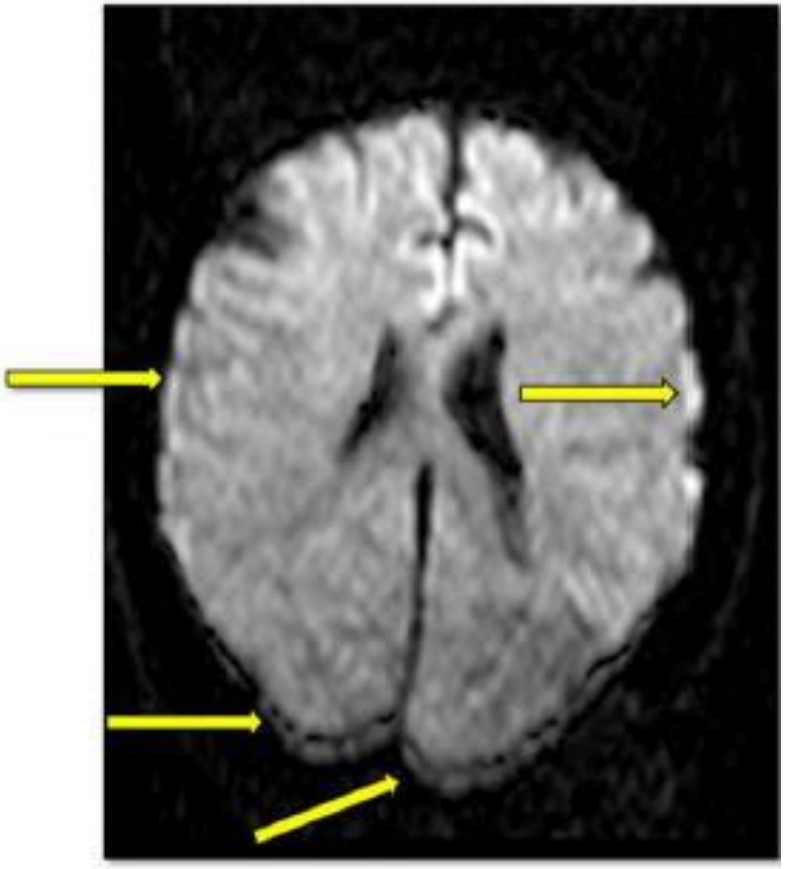
- Is spaced with mechanical precision

Then the artifact is most likely hardware related.



Eddy Currents

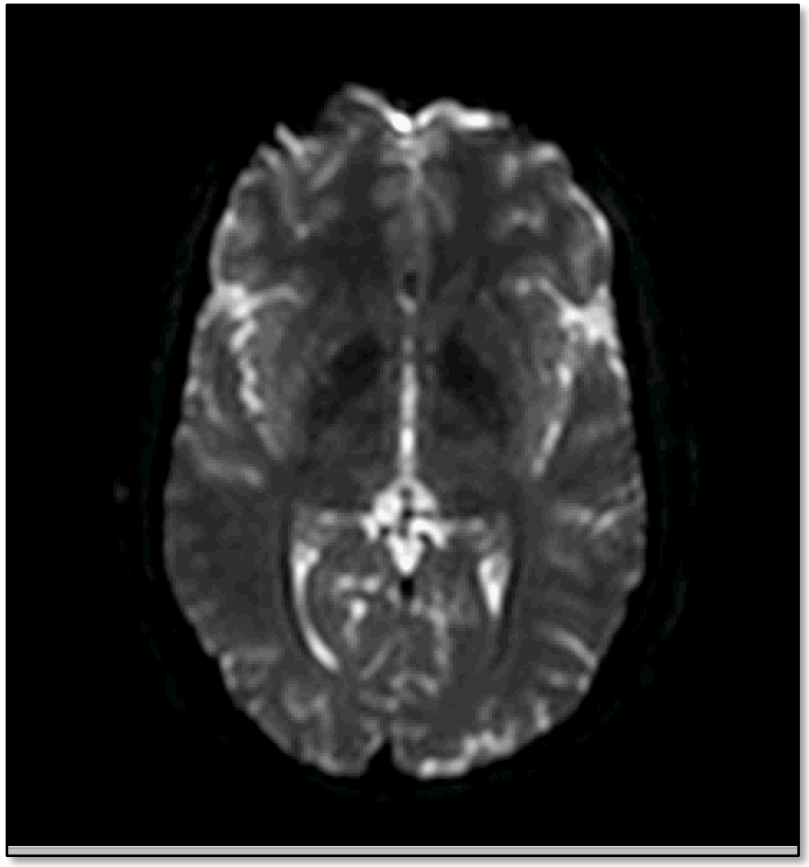
The double contour artifact is visible with SSh-DWI



Eddy Currents:

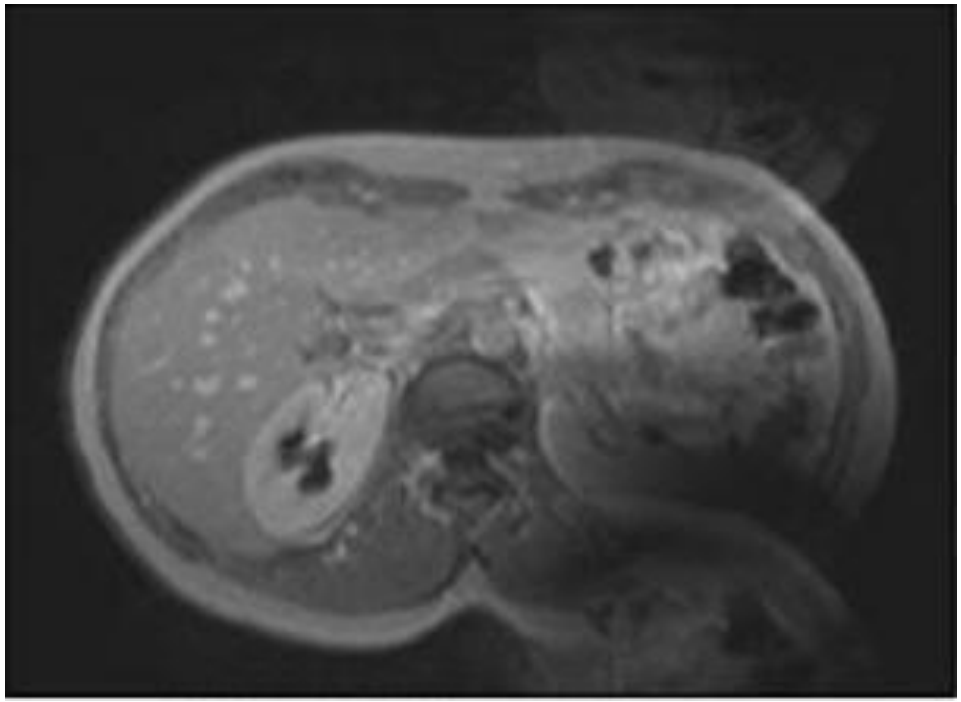
- Appear as if the brain is moving in the FOV.
- Especially visible in the phase direction.
- To view this problem:
  1. Run a DWI scan with single direction (set the **gradient overplus** to **no**)
  2. Play 1 slice in movie mode.

Eddy current compensation needs to be adjusted by the service engineer.

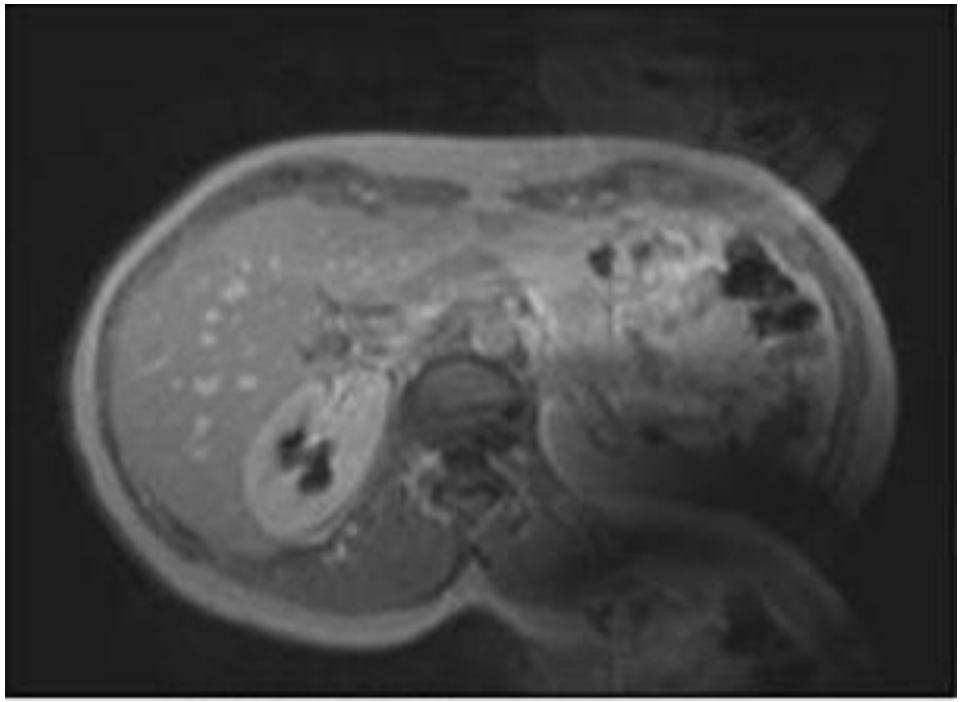



Sc 17
B-FFE/M
SL 3
Gd 406ms
A
A
L

Coil Element Failure



Coil Element Failure when using Sense



Spikes

Many sources possible

In this case, caused by a loose pin in coil.

Spikes are caused by a ‘bad’ data point in k-space, due to hardware or environmental influences, leading to:

- Zebra stripes
- Noise
- Data point artifact

In this example, spikes from gradient coil →

Other potential sources :

Loose components

Loose screws

Loose cabling

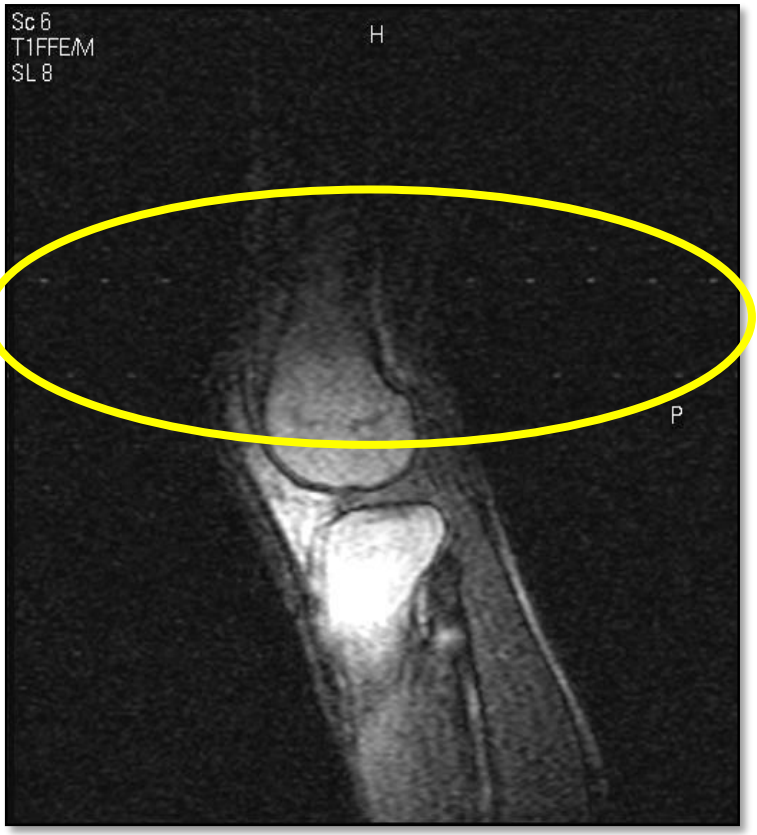
Mechanical vibration

Low humidity in scan room

Protocol related (high gradient demand)

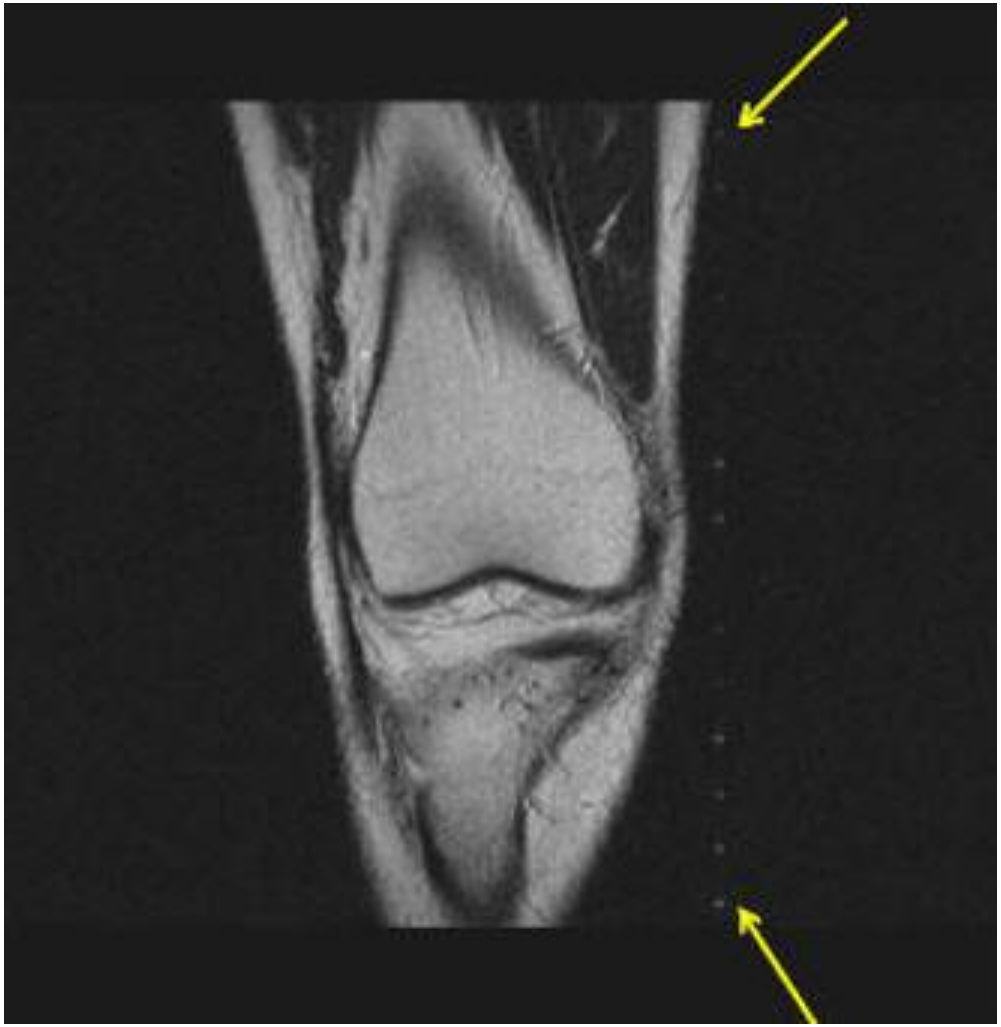
RF Interference

- RF disturbance in the scan room can cause:
  - Single dots
  - Line artifacts



Common causes:

- RF door open
- Poor integrity of RF room
- 3rd party equipment
- Broken light bulb

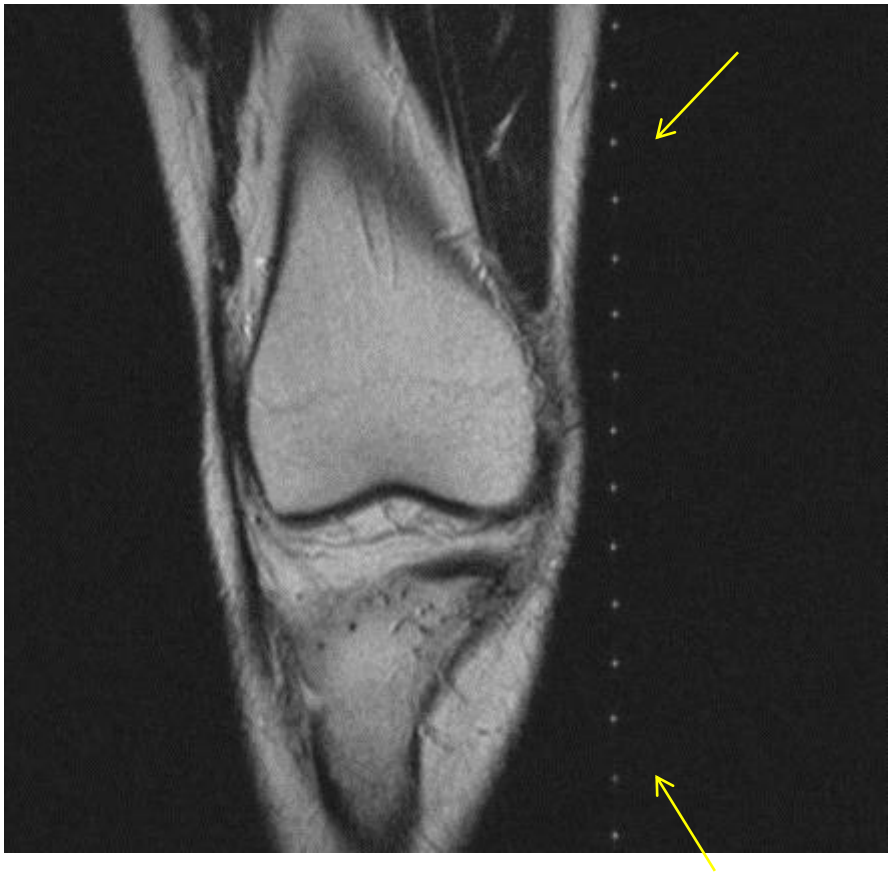


RF Interference

- Dots (zipper)

Cause:

- In this case, customer installed a mobile respiration device in the MR room.
- The power cable was routed into the RF cage through the wave guides and not through the RF cage filters.

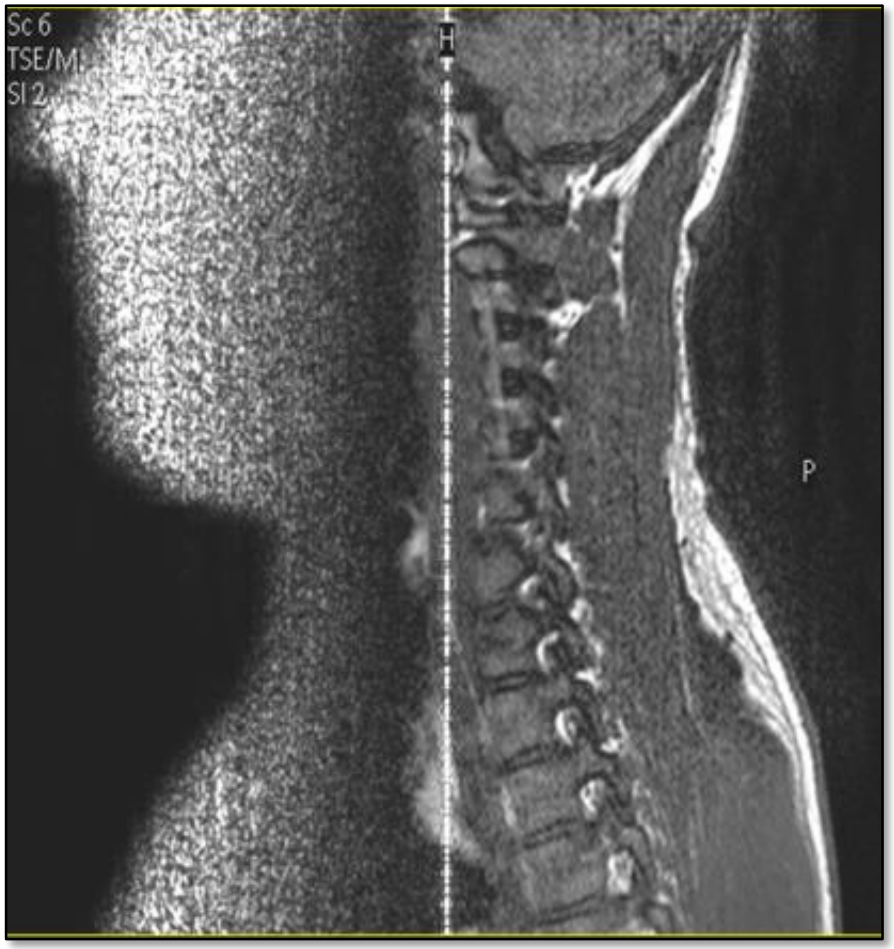


Spikes

Humidity in the scan room too low.

- Leads to arcing and sparking across components.
- Can appear as low signal to noise, linear artifacts, and grids.

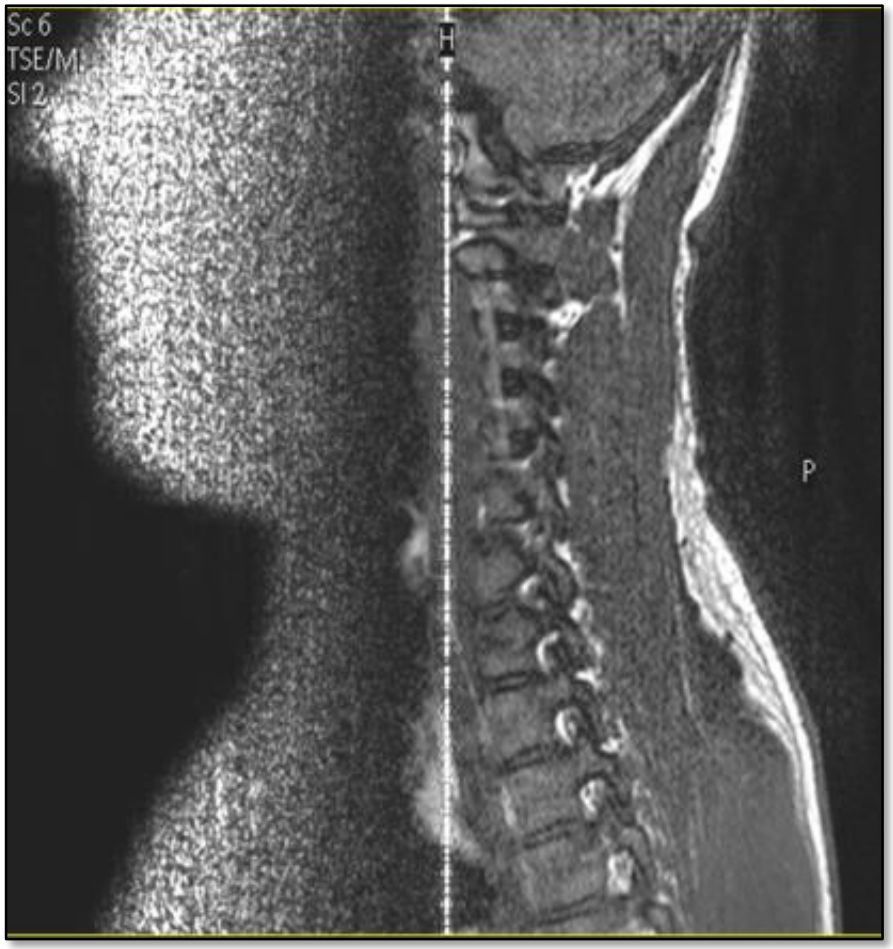
- Appeared as line artefact
- Occurred with all coils
- Affected one slice
- Intermittent occurrence



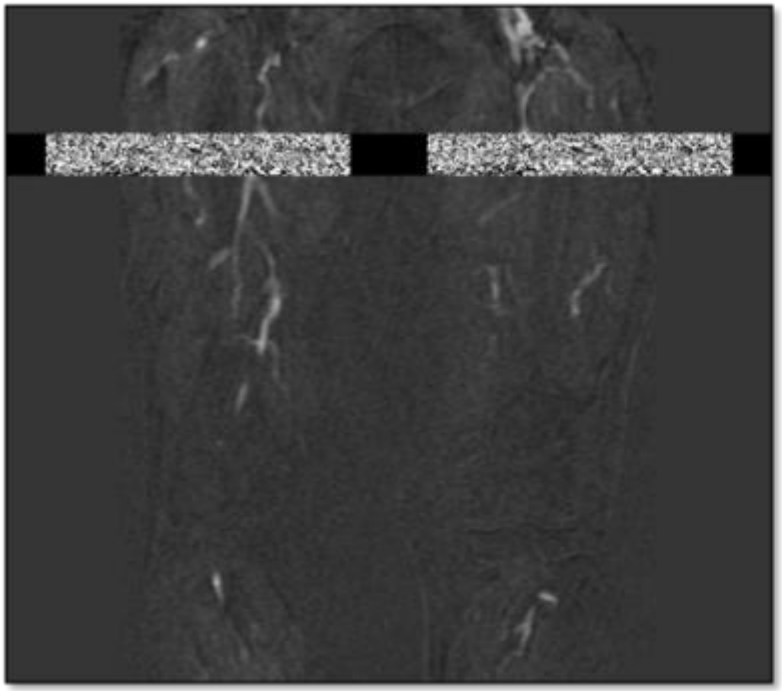
RF Interference

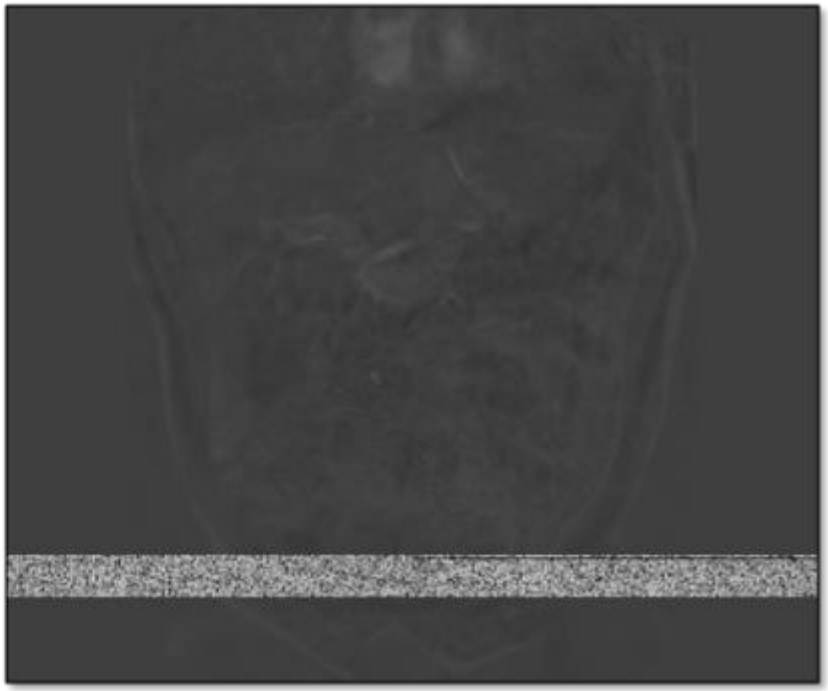
Cause:

- Defective filter in gradient cables



Band Artifact

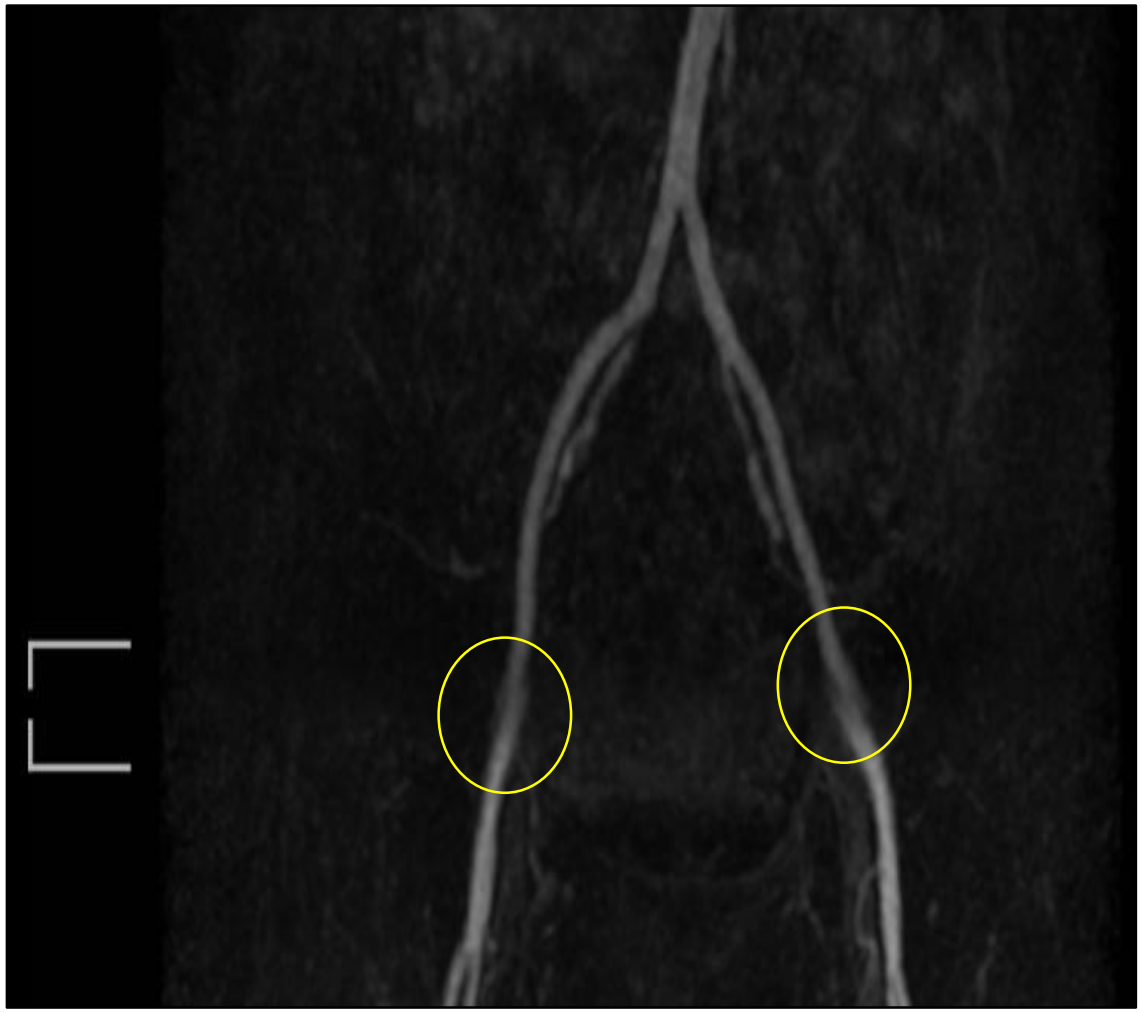




Software cause

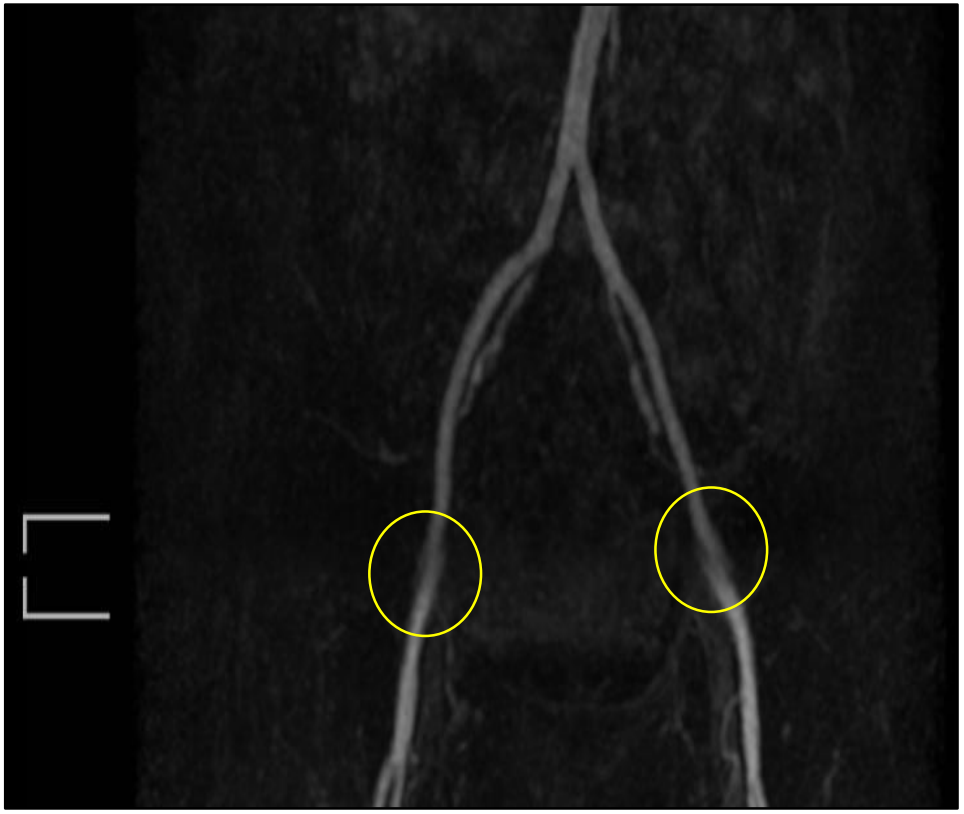
In this case, problem was resolved when the host computer was replaced.

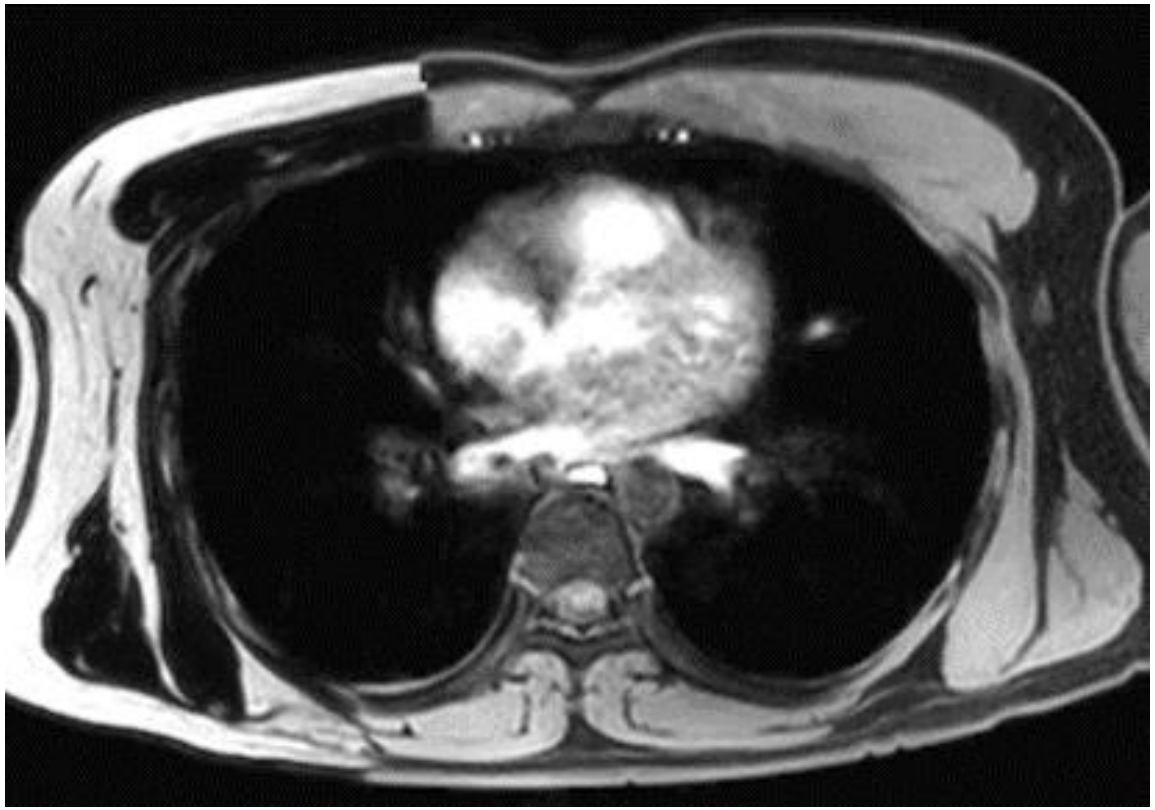
Software defects are corrected by Service Packs or new software release



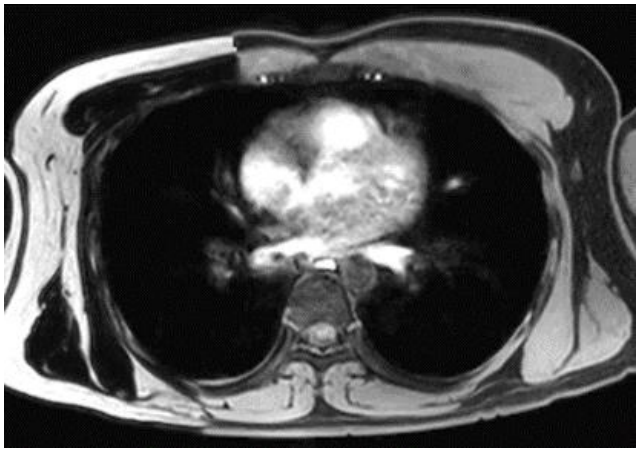
MobiView overlapping area

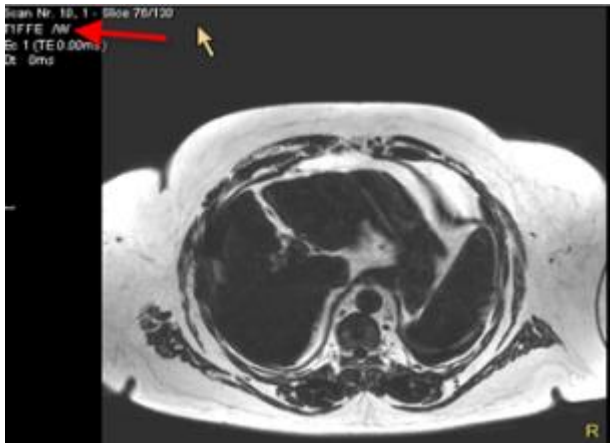
(multistack merging)





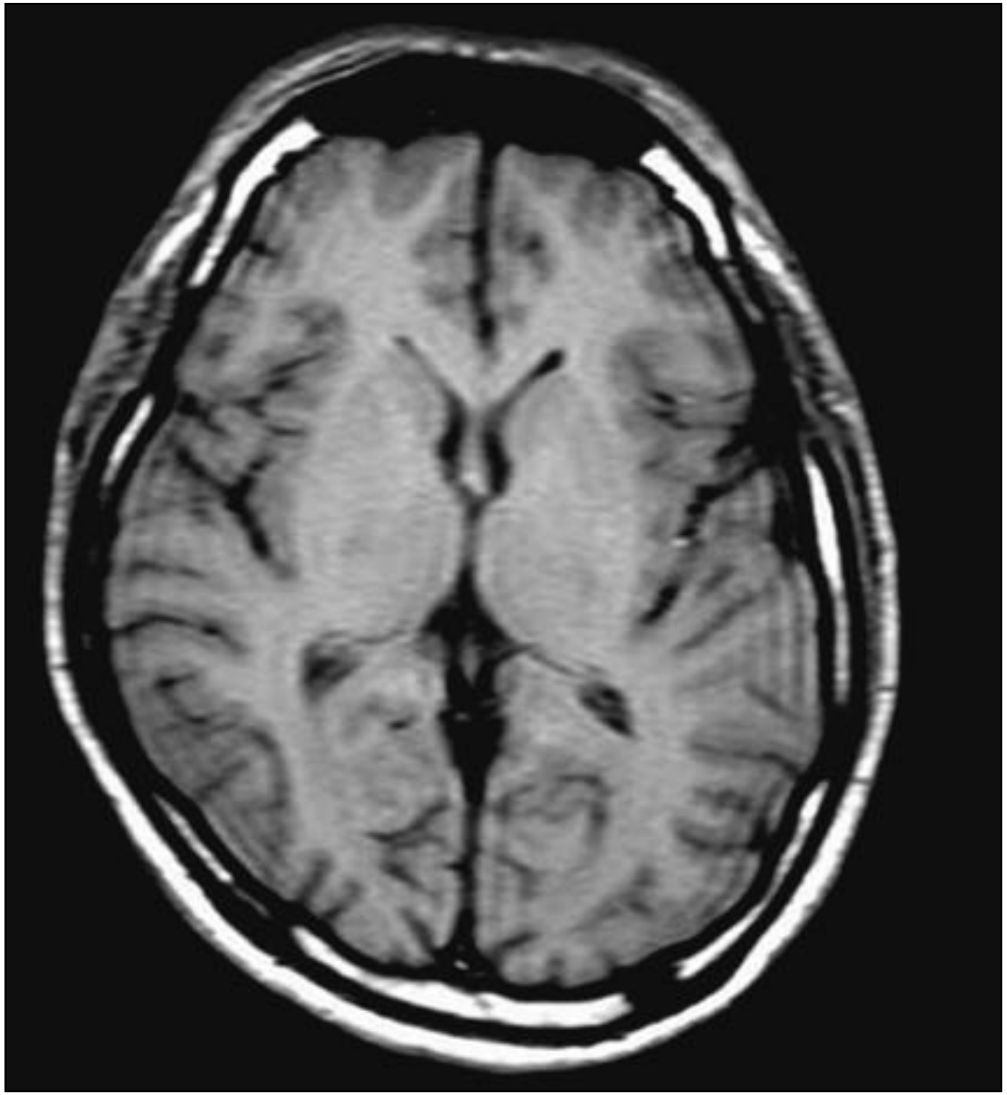
Reconstruction artifact





Swap artifact in mDIXON-FFE caused by incorrect calculation of Water and Fat reconstructions

- mDIXON_XD solve this problem, using 7 point fat modeling for better fat determination



Physics

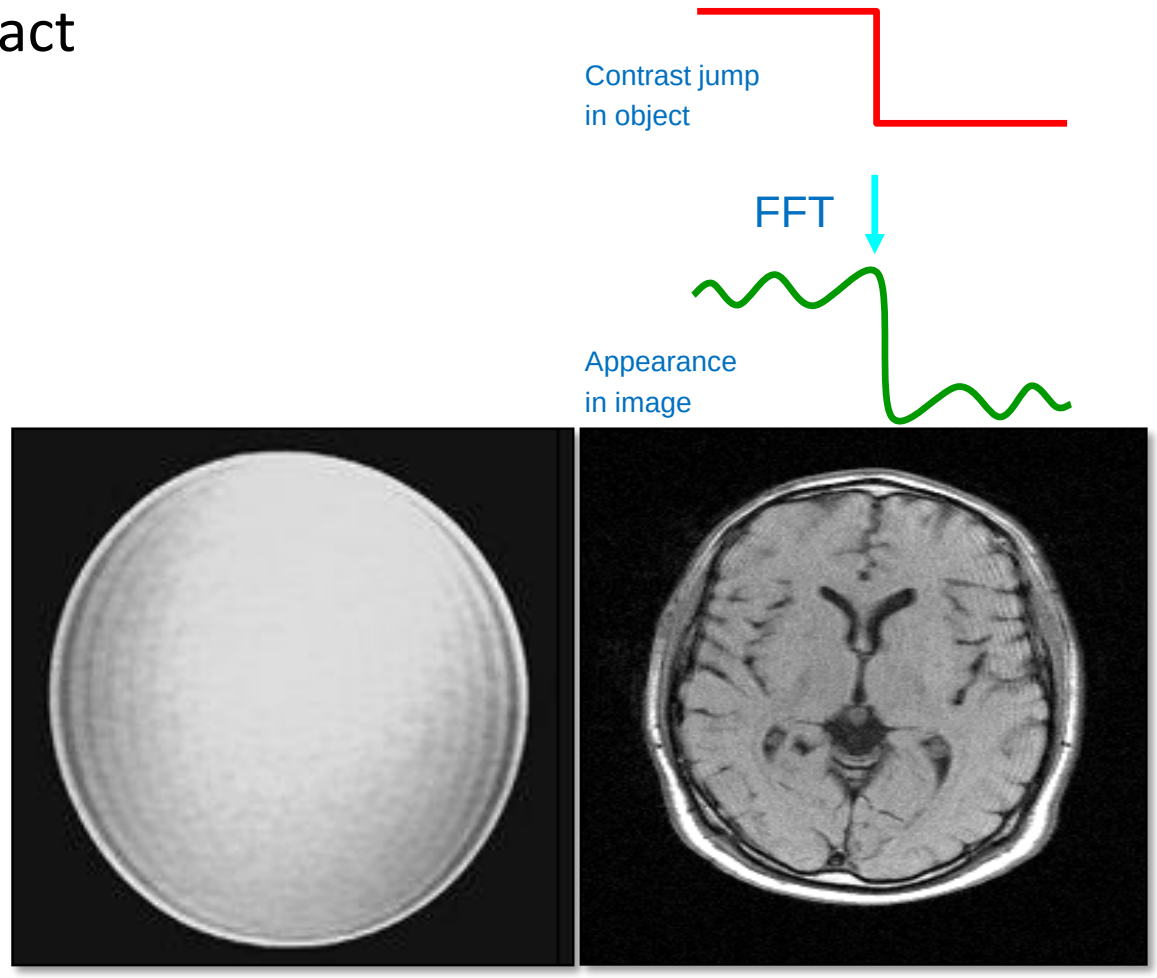
Reconstruction artifact

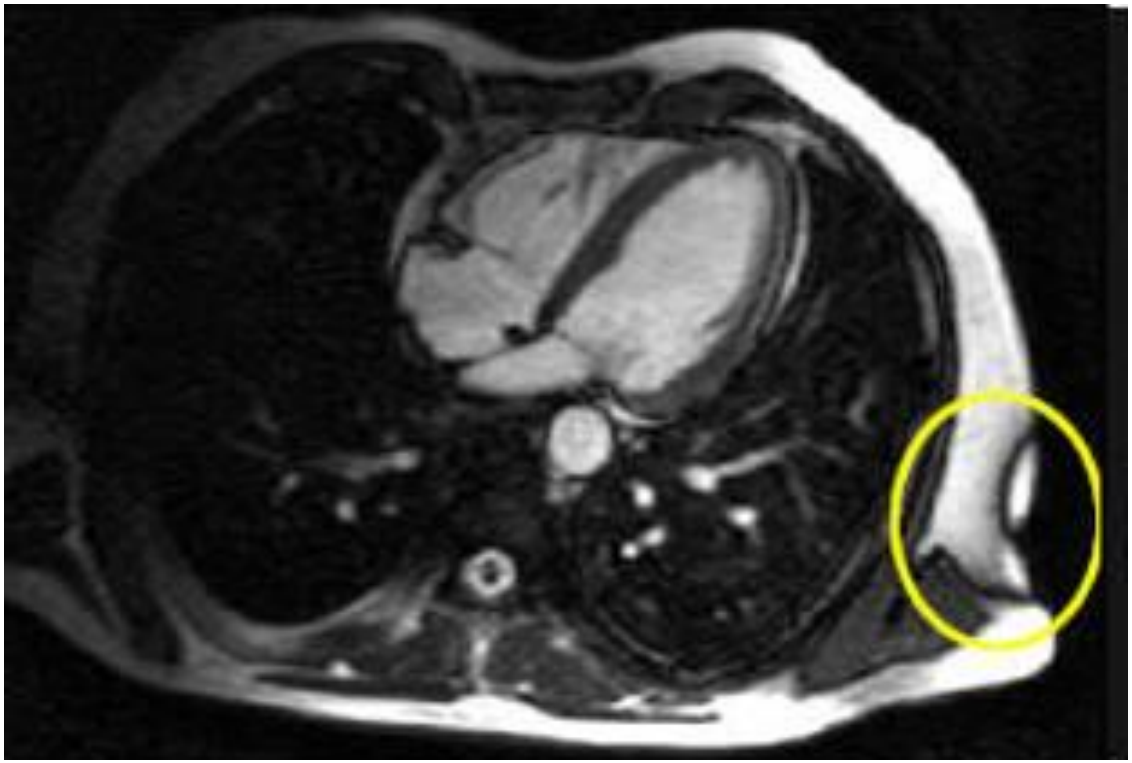
Truncation

- Other names:
  - Gibb's artifact
  - Ringing artifact
  - Spectral leakage

Seen with low matrix

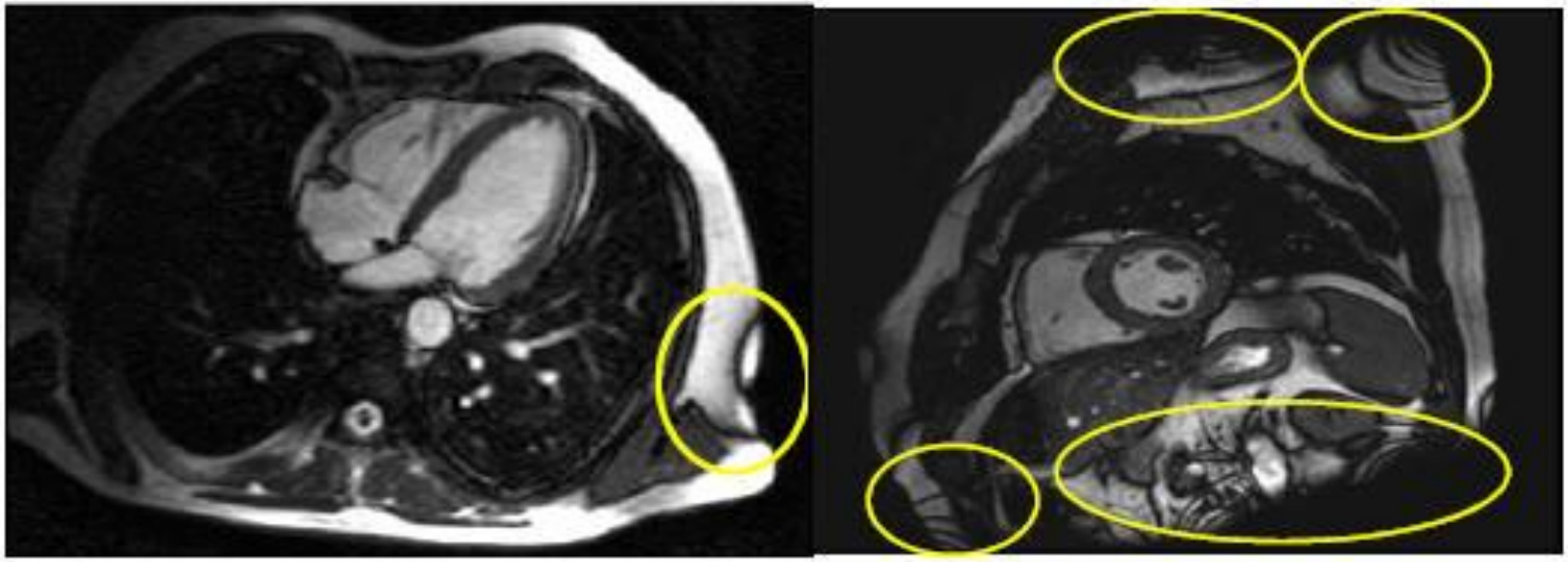
Phase matrix <<100%

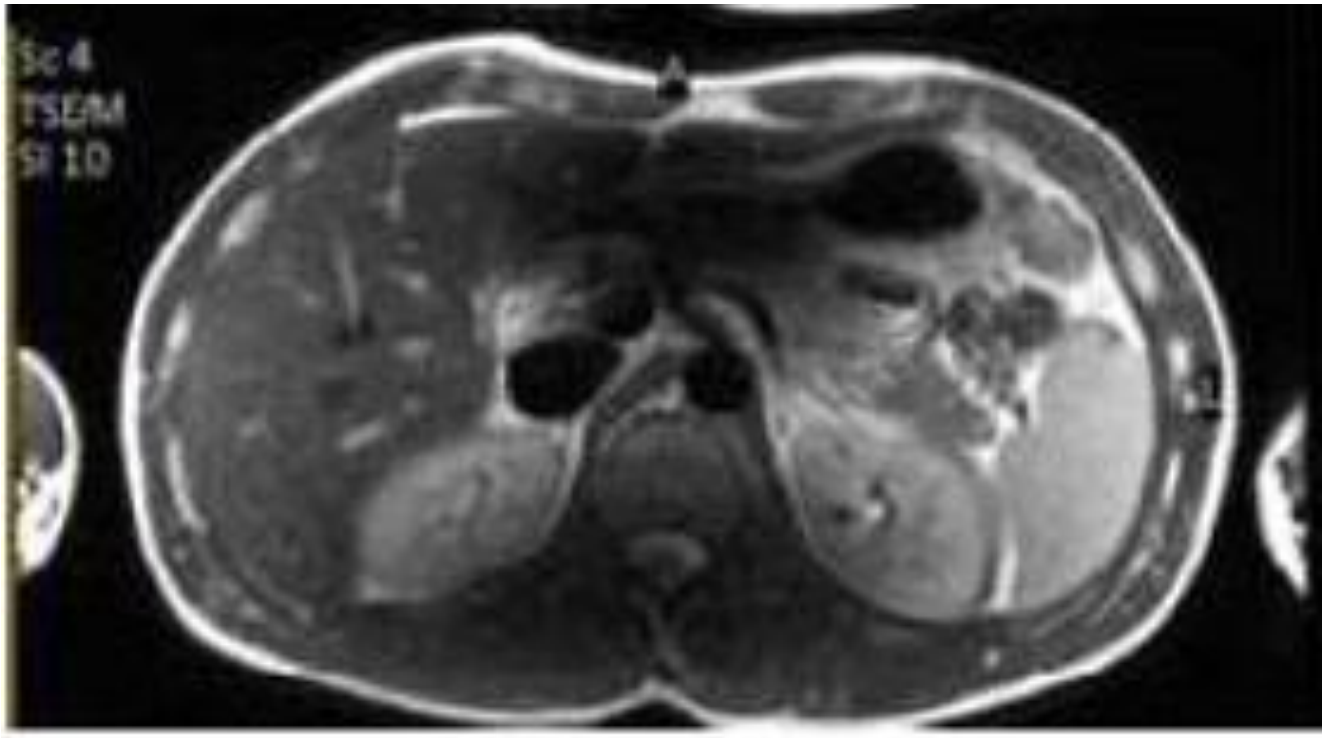




Off resonance banding in B-FFE

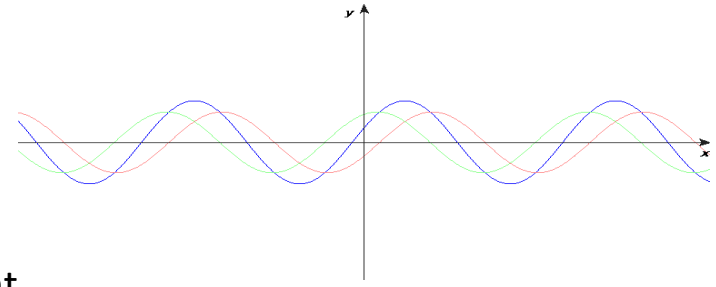
- Related to B0 Inhomogeneity
- Also related to contrast parameters
  - As TR increases, more bands appear.
  - As TE increases, bands move closer to image center.



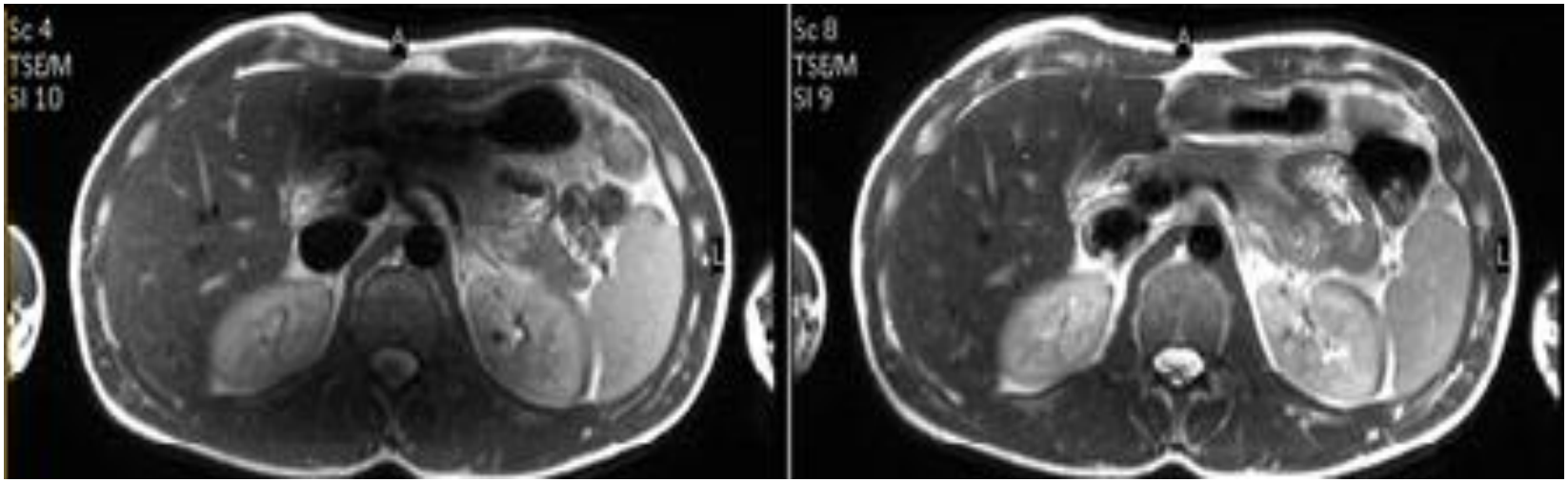

Sc 4
TSEM
SI 10

Physics

Dielectric Effect (B1 Shading)

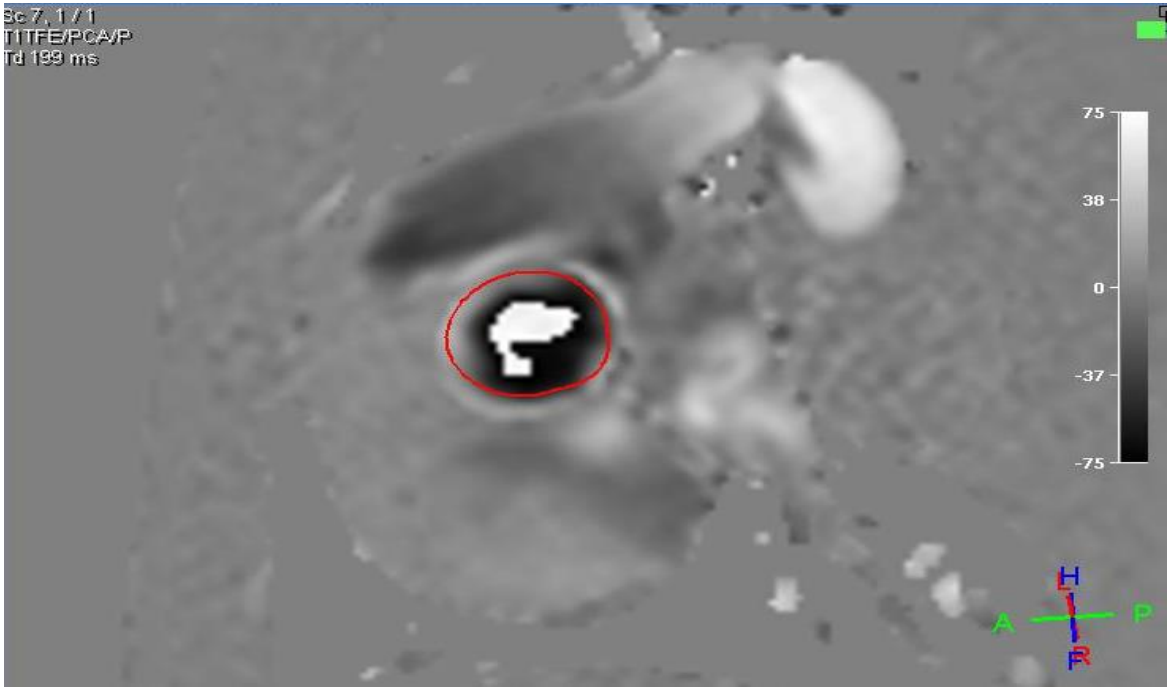


- Seen at high field strengths (3T and higher) due to:
  - Short RF transmitted wavelengths
  - Electrical conductivity of the tissue
- Leads to B1 disturbance → standing RF waves on the patient
- Resolved by multi-transmit (use simultaneously 2 different RF transmit sources)



Standard

Multi-Transmit


Sc 7, 1 / 1
T1TFE/PCA/P
Td 199 ms
75
38
0
-37
-75
H
A
P
F

Aliasing of velocity in Q-flow

- Velocity in the vessel > Venc

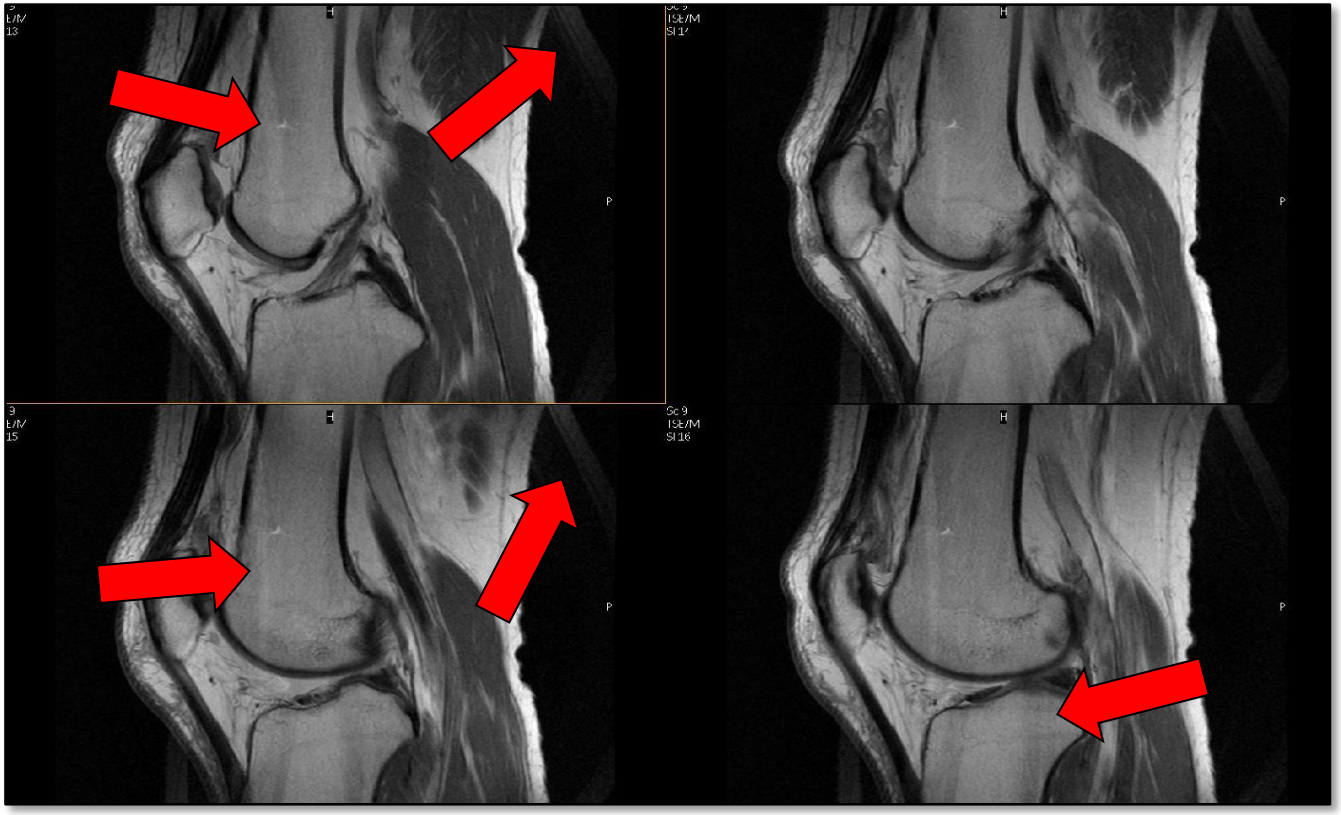
- Recommendation: Increase Venc of the sequence

Angio / Contrast enh.	phase contrast
Quantitative flow	yes
PC flow directions	FH
PC velocity (cm/s)	200

Name the Artifact(s)

Back folding

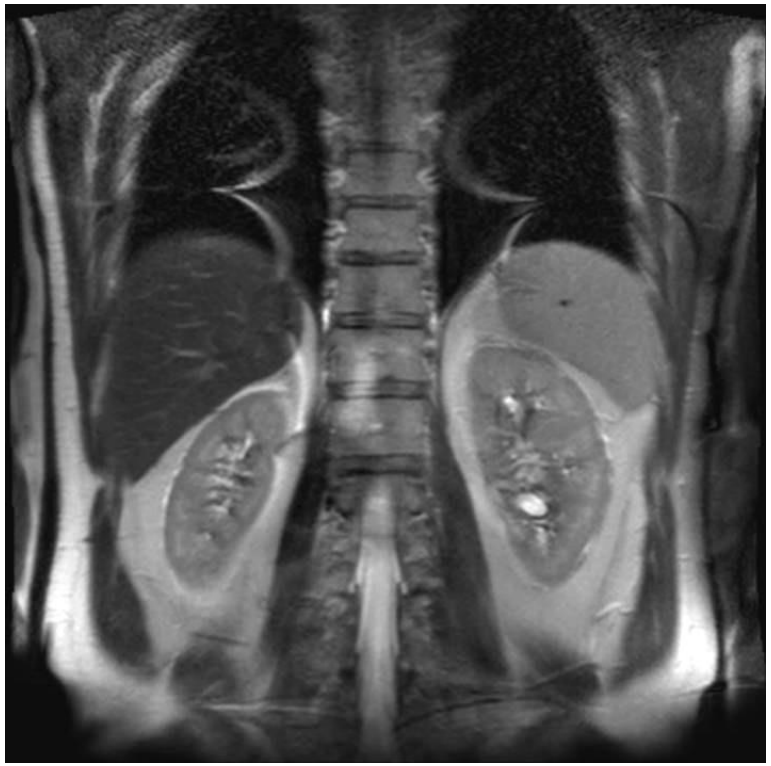
Back folding



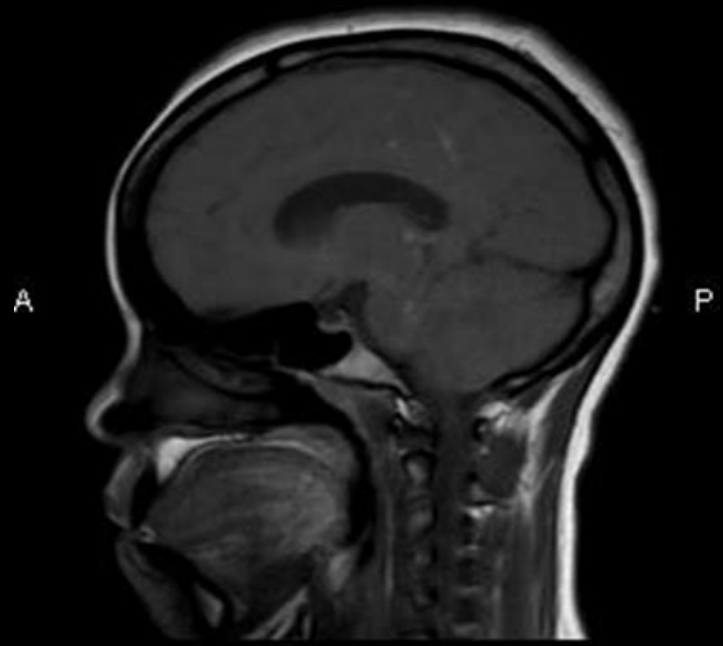
Back folding

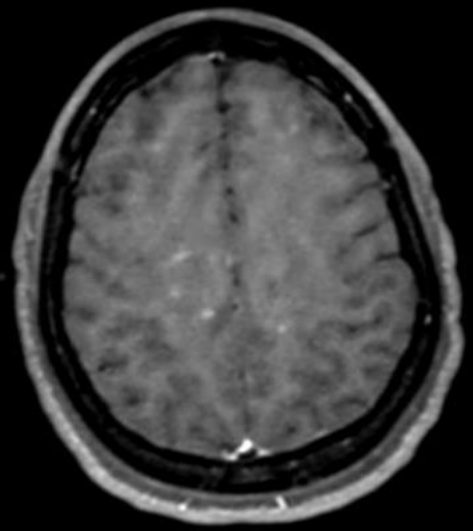
Back folding

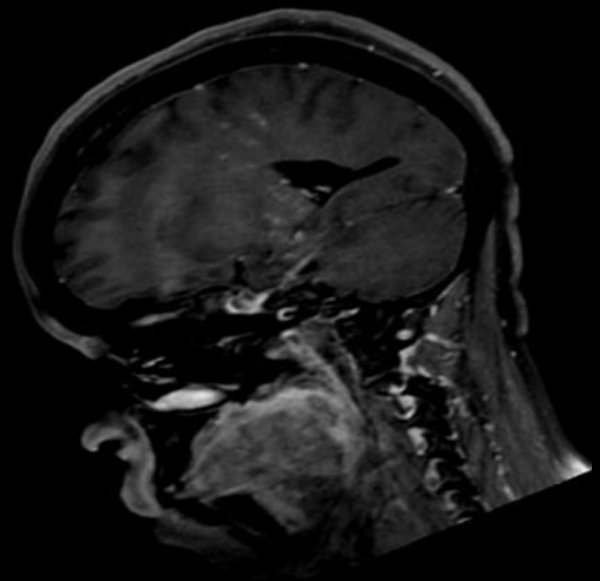
Blood flow (popliteal artery)

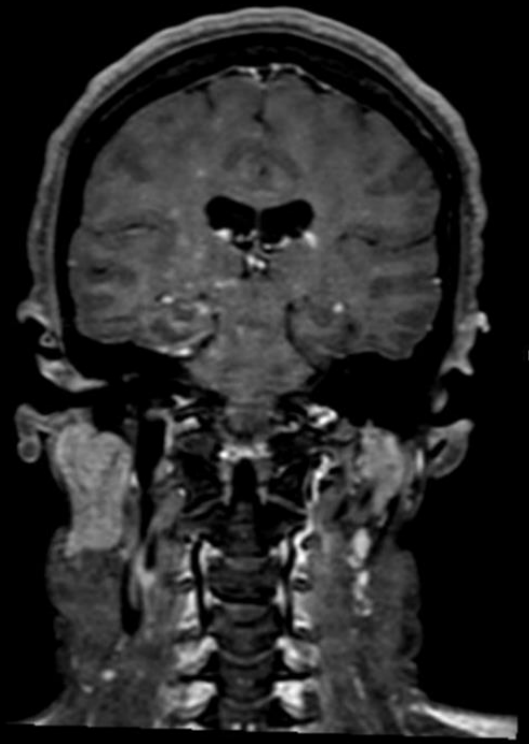


Aliasing of the arms with high sense factor


A
P

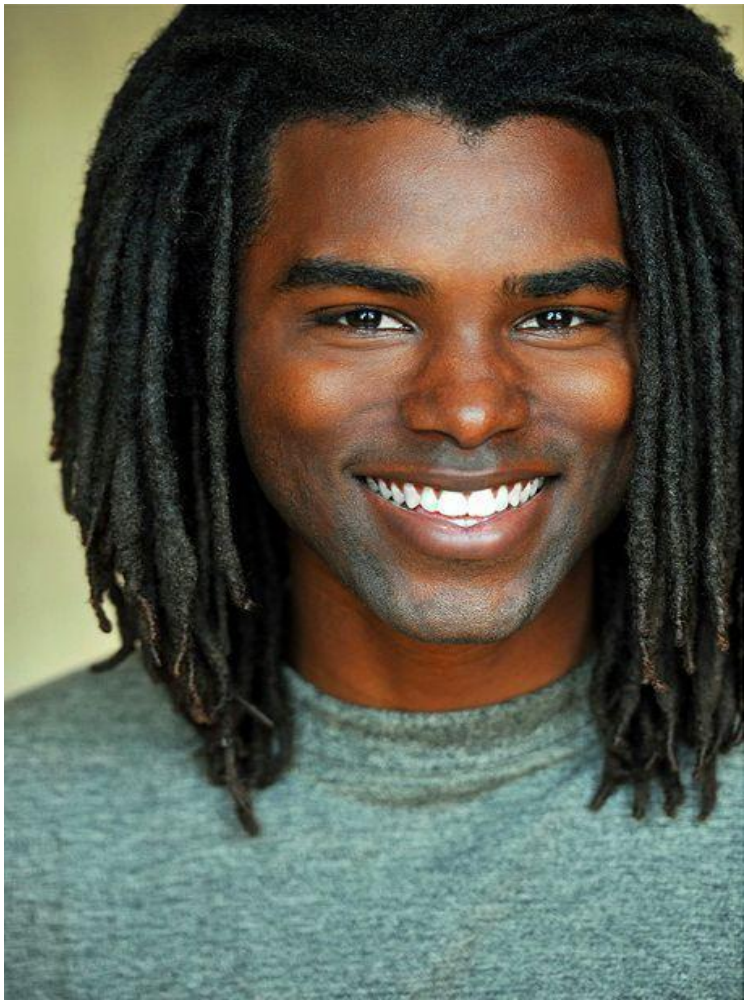

LH

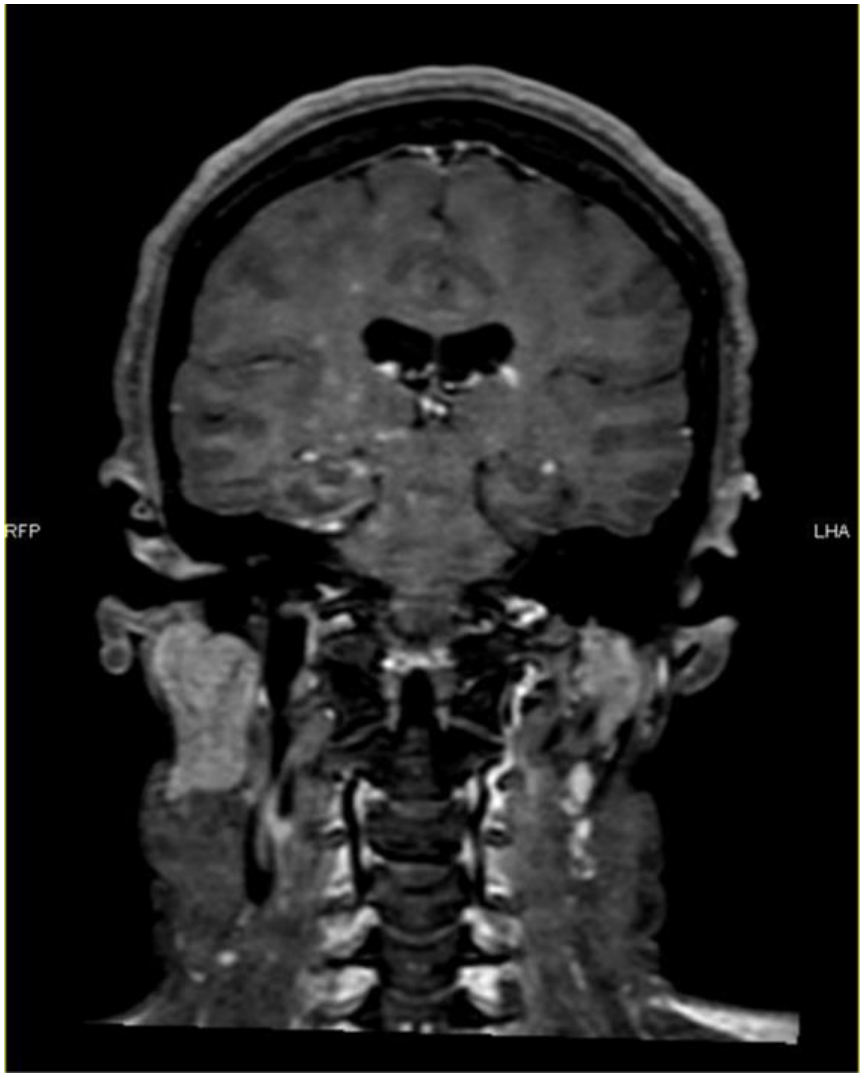




Dreadlocks are made with black beeswax

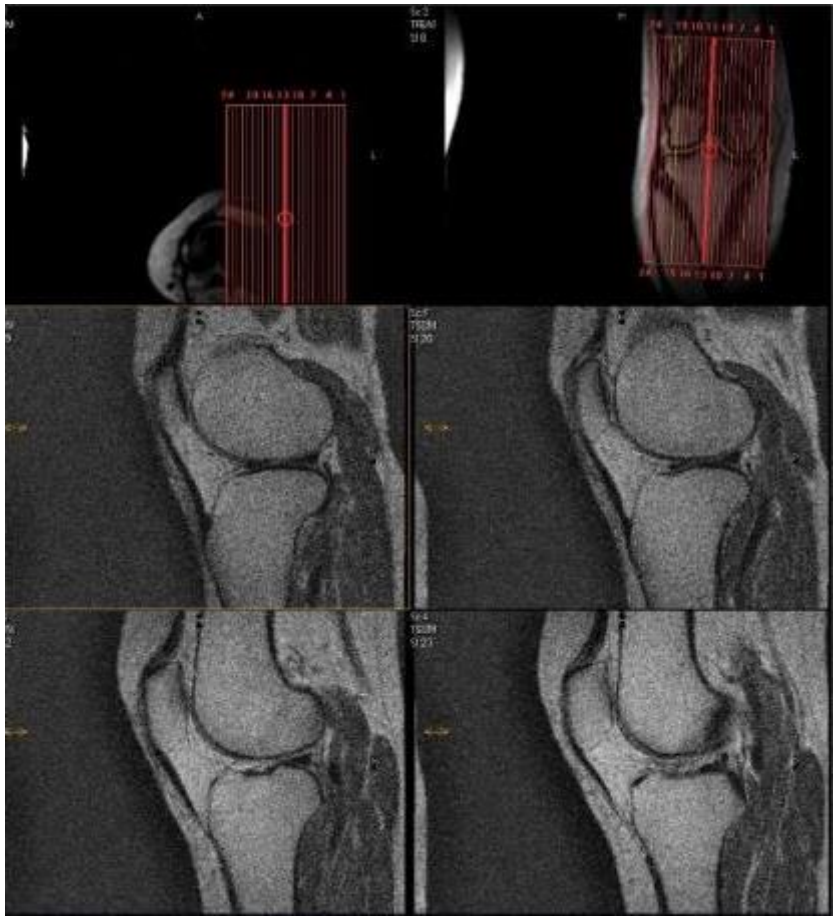
(black beeswax contains iron oxide particles)





Technical or application?

Technical or application? Radiographer ☺



They scanned the wrong knee ☺
The coil is on the other knee

THANK YOU!