Al-Mustaqbal University
College of Health and Medical Technologies
Radiological Techniques Department

Magnetic Resonance Imaging

First Semester

Lecture 9: Artifacts and their compensation

2025/2024

Introduction:

Magnetic resonance imaging also suffers from artifacts as other radiological modalities. Artifacts can cause **significant image degradation and can lead to misinterpretation**. It is impossible to eliminate all artifacts though they can be reduced to acceptable level.

Scientific Content:

Artifacts may be defined as **the false features in the image produced during the imaging process**. Artifacts can be **rectified** easily when the causes are known.

- and these include the following:

1- Ghosts/Motion Artifacts:

Ghosts are replicate of something in the image. **Ghosts are produced by body part moving along a gradient during pulse sequence resulting into phase mismapping**. **Ghosts can originate from any structure that moves during the acquisition of data** (Fig. 1). Periodic movement such as **respiratory, cardiac and vessel pulsation** causes ghosts while nonperiodic movement causes a smearing of the image. **Artifacts can be classified into different categories**

-Axis: ghosts almost always seen along **phase encoding axis**.

-Corrective measures:

A-Patient motion: Make patient lie comfortably, stabilize, with straps and cushions, it is important not to use excessively long sequences, as movement for a brief period spoil all the images.

B- Cardiac motion : **This type of artifact is caused by the contraction and relaxation of heart (chest) while the scanning is going on**.

To avoid this type of artifact, **cardiac gating** is mandatory during the procedure.

C- Respiratory motion : This type of artifact is caused by respiration during the scanning. This can be avoided by **respiratory gating and respiratory compensation.**

D- Blood flow motion: This type of artifact is caused by the flow of blood throughout the cardiac cycle. The artifact is prominent in **axial images**. **An effective remedy for blood flow motion artifact is 'Spatial Presaturation (SAT)** which is a new technique for suppressing these artifacts.

In this technique a spectrally shaped radiofrequency pulse has been applied to selectively saturates spins located in regions outside the image volume.

Note: **Another way to reduce the effect of the motion artifacts** is by the using of **saturation band.**

-**Saturation Band It is also called REST slab or SAT band and is used to suppress the signal from a part of the FOV** (Fig. 2). A 90 degrees RF pulse is sent immediately prior to proper sequence tilting the magnetization in transverse plane in the region of the band. When proper excitation pulse follows there is no longitudinal magnetization in this region to be tilted. Hence this region will not have any signal.

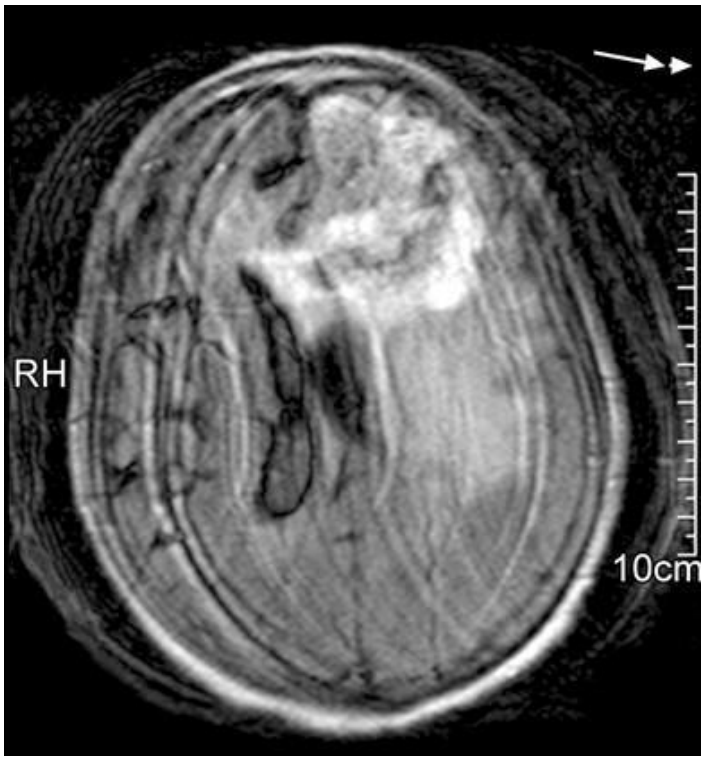

Fig.1: Ghosting/ Movement artifacts

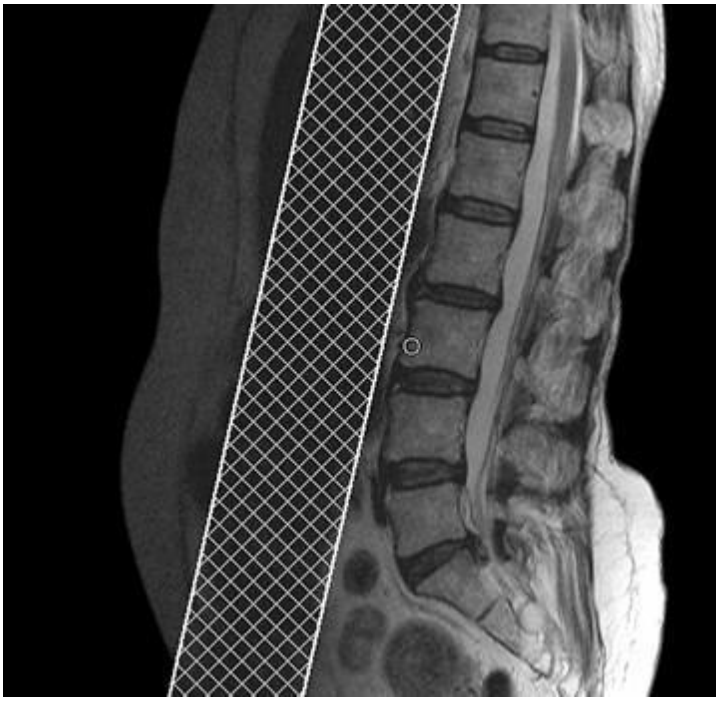

Fig. 2: Image showing saturation band anterior to the spine.

2- Aliasing/ Wraparound:

In aliasing, anatomy that exists outside the FOV appears within the image and on the opposite side (Fig. 3). When the imaging field of view is smaller than the anatomy being imaged, aliasing occurs.

-Axis: aliasing can occur along any axis.

Aliasing along frequency encoding axis is called **frequency wrap** and along phase encoding axis is called **phase wrap**. Aliasing can occur along slice selection axis in 3D imaging.

- Corrective measures:

A-Increase FOV.

B- Filtering the frequency encoded direction.

C- Phase wrap can be corrected by increasing FOV along phase encoding direction.

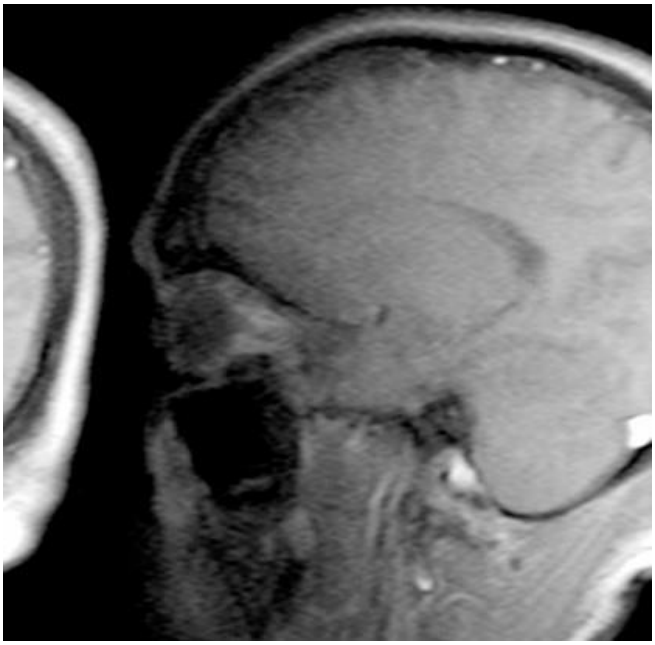

Fig 3: Aliasing artifact

3- Chemical Shift Artifacts:

Chemical shift artifacts appear **at the interfaces between water and fat because the precessional frequency of protons is slightly different in these two substances**. This difference in precessional frequencies of protons in water and fat is called '**chemical shift'**. It is expressed in parts per million (ppm). The frequency of water protons is about 3.5 ppm greater than that of fat protons. This chemical shift of 3.5 ppm causes water protons to precess at a frequency 220 Hz higher than that of fat proton at 1.5 Tesla. **This leads to misregistration of the signals. They are displayed** by the equipment as **dark region of signal void on one side of water containing tissue and a region of bright signal at the other end of the water fat interface due to super imposition of fat and water signals on the frequency encoding direction.** The chemical shift artifacts are commonly noticed in the **abdomen, spine and orbits where fat and other tissues from boarders**. **This artifact is greater at higher field strength**. (fig.4).

-Axis: Frequency encoded direction.

- Corrective measures: The only way to eliminate this artifact is **to use a fat suppression technique.**

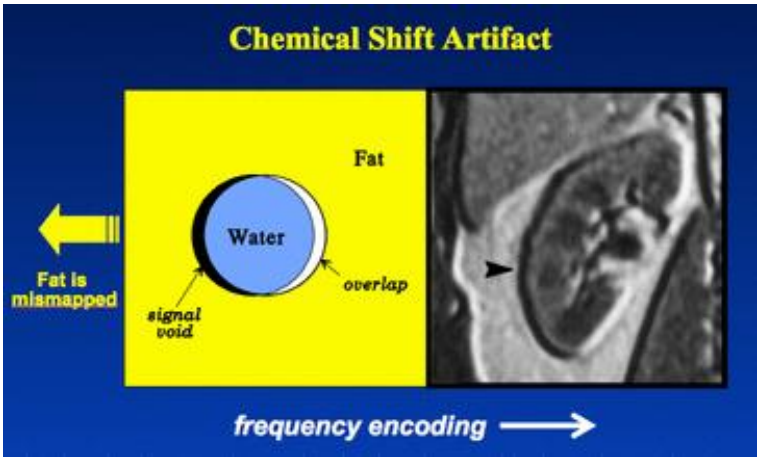

Fig 4: Chemical shift artifact

4-Gibbs or Truncation artifacts:

Gibbs or Truncation artifacts **are bright and dark lines that are seen parallel and adjacent to boarders of abrupt intensity change**, as many be seen at **CSF, spinal cord, fat and muscle**. (fig.5)

-Axis: Phase encoding direction.

- Corrective measures: Gibbs artifact can be reduced by **increasing the matrix and using a filter.**

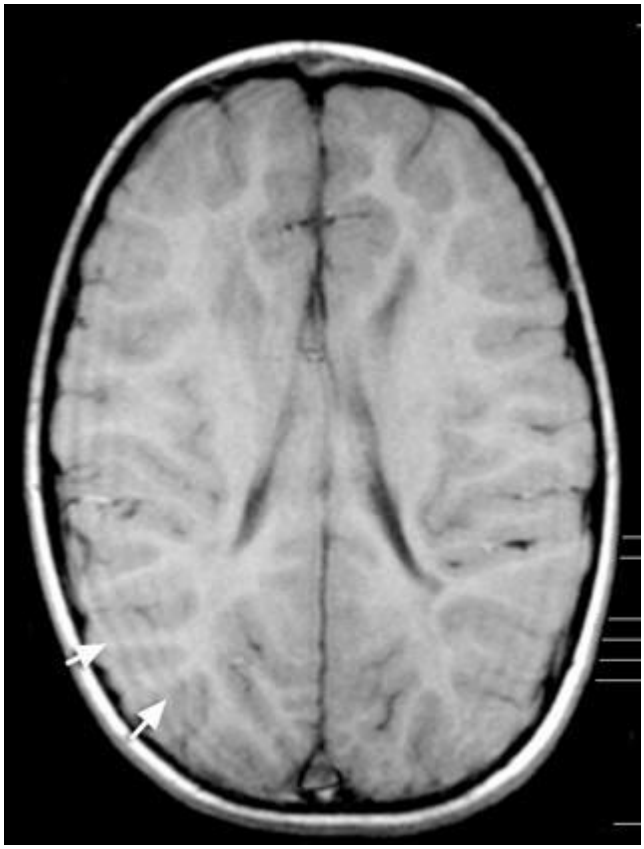

Fig 5: Gibbs artifact

5- Magnetic Susceptibility Artifact:

Magnetic susceptibility is **the ability of a substance to become magnetized**. Some tissues magnetize to different degree than other, resulting into differences in precessional frequency and phase. **This causes dephasing at the interface of these tissues and signal loss.** For example, magnetic susceptibility difference between **soft tissues and air is about 10 ppm.** This causes signal loss and distortion of the boundaries of the brain near air sinuses. Other common causes of magnetic susceptibility artifacts include metal. (fig.6)

-Axis: Frequency encoding and phase encoding.

- **Corrective measures**: Use of **SE sequence and remove the metal.**

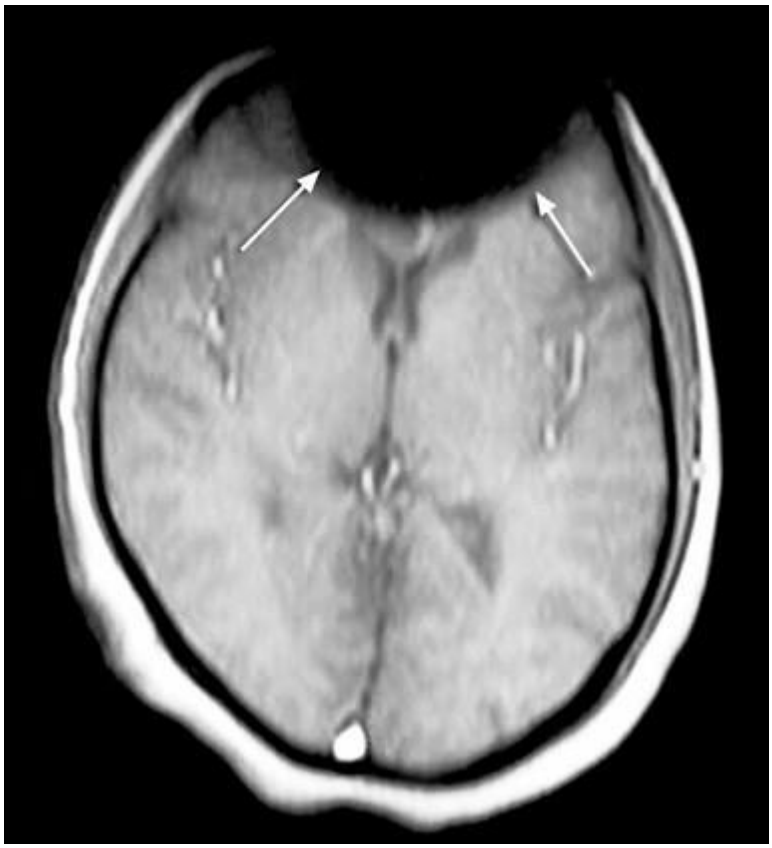

Fig. 6: Susceptibility artifact

6- Zipper Artifacts:

This artifact is caused by external RF entering the room at a certain frequency and interfering with inherently weak signal coming from the patient. There are various causes for zipper artifacts in images. Most of **them are related to hardware or software problems. The zipper artifacts that can be controlled easily are those due to RF entering the scanning room when the door is open during acquisition of images**. RF from radio transmitters will cause zipper artifacts that are oriented perpendicular to the frequency axis of the image. Fig.7

-Axis: Perpendicular to the frequency axis of the image.

-Corrective measures: System generated artifacts should be reported service engineer.

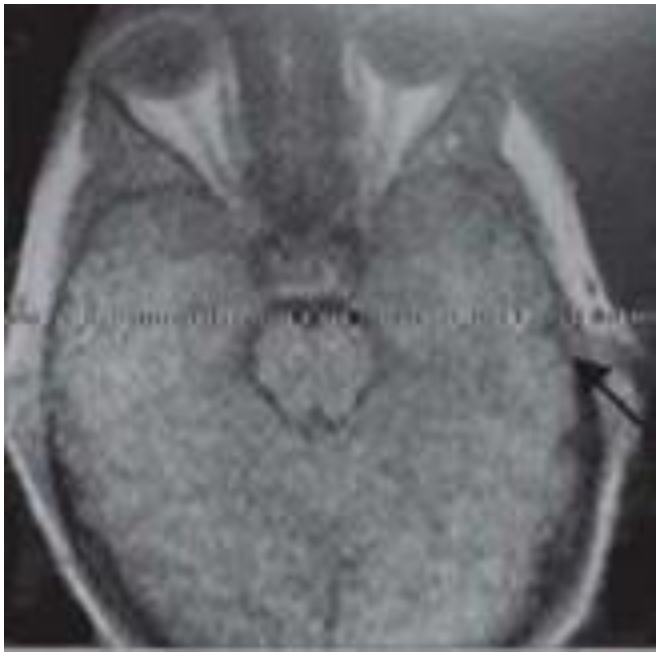

Fig 7: Zipper artifact

7- Shading Artifacts:

In shading artifact image has uneven contrast with loss of signal intensity in one part of the image (Fig. 8). The causes include uneven excitation of nuclei within the patient **due to RF pulses applied at flip angles other than 90- and 180-degree, abnormal loading of coil or coupling of coil and inhomogeneity of magnetic field.**

-Axis: Frequency and phase encoding.

-Corrective measures:

1. Load the coil correctly.
2. Shimming to reduce the inhomogeneity of the magnetic field.

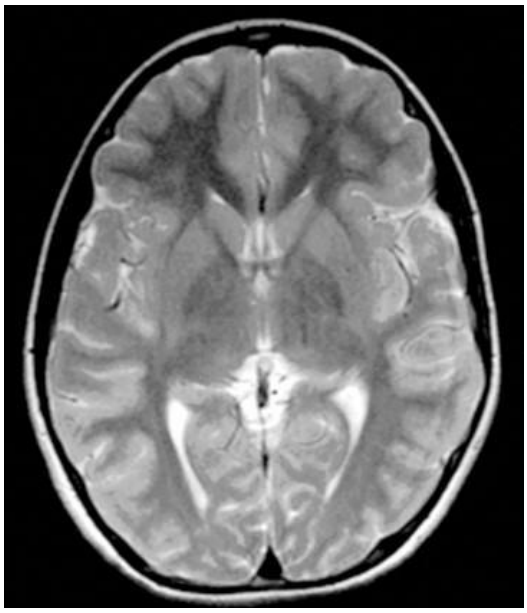

Fig. 8: Shading artifact: T2-w axial image of the brain shows comparatively less signal in the frontal regions. This was because of the improper loading (connection) of the coil in the anterior part.

8- Cross Excitation:

An RF excitation pulse is not exactly square. As a result, nuclei in slices adjacent to the one excited by RF pulse may also receive energy and be excited. This energy flips NMV of these nuclei into transverse plane. When they are excited by their own RF excitation pulse, they do not have enough longitudinal magnetization to be tilted. This results in reduced signal intensity in the adjacent slices. This phenomenon is called **cross excitation** (Fig. 9).

-Axis: Slice selection gradient.

-Corrective measures: Increase inter-slice gap.

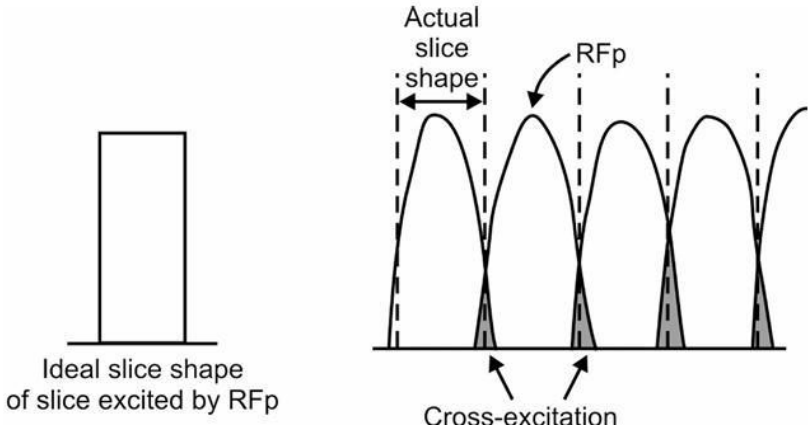

Fig 9: Cross Excitation: Diagram shows excitation of nuclei in the adjacent slices because of parabolic shape of the slice excitation