LETTER TO EDITOR

MRI Artifacts

Magnetic resonance imaging (MRI) has become more and more frequently used in medical imaging diagnosis in the recent years. Radiologists and technicians working at these systems are relatively often confronted with image artifacts related to the radiowave with strong magnets in the scanner. Numerous artifacts are associated with MR scanning.[1-4] With an understanding of their cause, many may be corrected, minimized, or avoided, either at the source before data acquisition or at the reconstruction stage after data acquisition. This requires familiarity with the scanner design, the theory of operation and image acquisition. Therefore, this article presents the most relevant artifacts occuring in MRI, providing physical background on the formation of artifacts and suggesting strategies to reduce or avoid these artifacts. Motion-related; para-magnetic; phase wrap; frequency; susceptibility; clipping; chemical shift and zebra artifacts are the most frequent MRI artifacts.

Motion-related artifact: Motion artifacts occur as a result of movement of tissue during the data acquisition period due to respiration, pulsation or motion, through the gradient magnetic field, hence acquiring an additional phase shift. They are manifested as signal misregistrations in the phase encoding direction than the readout direction because the encoding of phase by GPE occurs prior to signal detection.[5] An example of motion artifact is clarified in Figure 1.

The below measures may minimize the defect:

1- Changing the direction of phase encoding may exclude the ghosting image, which occurs only in this direction of the area of interest.

2- Gating the imaging sequence to the respiratory or cardiac cycle of the patient. For example if the motion is caused by pulsing artery, one could trigger the acquisition of phase encoding steps to occur at a fixed delay time after the R-wave in the cardiac cycle.[6]

Para-magnetic artifact: Para-magnetic artifacts are caused by metal deflecting the magnetic field, therefore changing the resonance frequency beyond the range used in MRI. The protons will not react to the RF excitation pulse and therefore, will not be displayed. The size and shape of the artifact depends on the size, shape, orientation, and nature of the metal and the pulse sequence used for the scan (Fig. 2).

Aluminium and titanium produce much less severe artifacts. Patients with a titanium hip or knee implant can go into a MRI scanner without any problems.[7] This arifact may be reduced by:

1- Asking the patients to remove all their metal items before the scan.

2- Checking whether the patients have aneurysm clips and metal implants, since most implants may obscure the anatomy under examination.

3- Using spin echo sequence to reduce this kind of artifact.

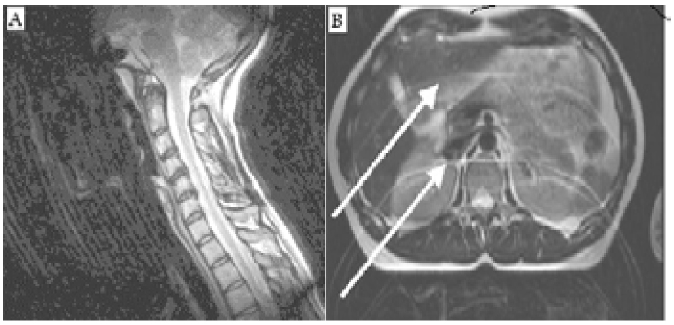

Fig. 1. Motion artifact
A. Sagittal T2-weighted image of the cervical spine with pulsation artifact.
B. Axial image of the abdomen showing motion artifact.

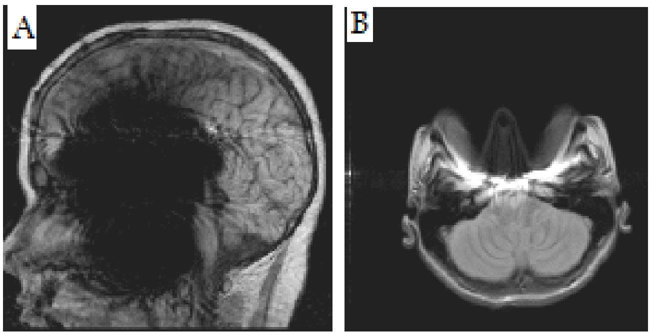

Fig. 2. Para-magnetic artifact
A. Sagittal image of the brain showing surgical clip artifact.
B. Axial image of the brain shows area distortion due to dental implant.

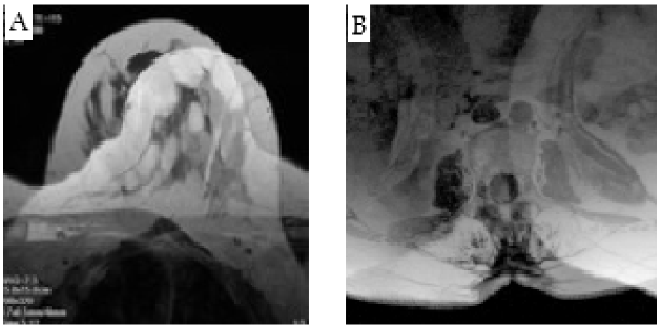

Fig. 3. Phase wrap artifacts
A. Sagittal breast MRI images demonstrating wrap artifact.
B. Axial lumbar spine MRI showing wrap artifact.

Fig. 4. Coronal MRI image of the abdomen showing susceptibility artifact.

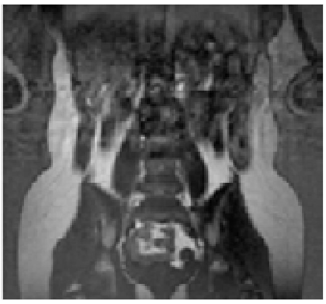

Fig. 5. Coronal MRI image of the pelvis showing clipping artifact

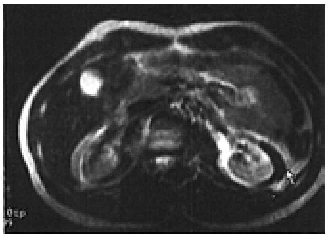

Fig. 6. T2-weighted MRI of the abdomen. The arrow demonstrates chemical shift artifact at the border of the left kidney.

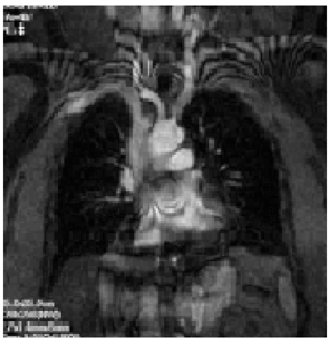

Fig. 7. Coronal MRI image of the chest showing zebra artifact.

Phase wrap artifact: Aliasing in the readout direction occurs when tissue outside the chosen FOV is excited. This may occur if an FOV smaller than the anatomical slice is selected. The frequencies for this tissue exceed the Nyquist limit for sampling conditions and are mapped to a lower frequency, a situation known as high-frequency aliasing or frequency wrap-around and aliasing can occur along both the frequency and phase axis.

Enlarging the FOV may compensate for the defect (Fig. 3).

Frequency artifact: Frequency artifacts are caused by 'dirty' frequencies; which may be the result of faulty electronics, external transmitters, RF-cage leak, non-shielded equipment in the scanner room, metal in the patient, leaving the door to the scanner room open.

Susceptibility artifact: Susceptibility is the ability of substances to be magnetized, e.g. iron in blood.[8] Susceptibility artifacts are caused by local magnetic field inhomogeneity. Tissues (cortical bone) or air-filled organs (lungs or bowel) contain little polarizable material and have very small susceptibility values. Soft tissue has a greater degree of polarization and a larger susceptibility. At the interface between soft tissues and the area of different susceptibility, a significant change in the local magnetic field is present over a short distance, causing an enhanced dephasing of the protons located there (Fig. 4).

Clipping artifact: Signal clipping or 'over flow' occurs when the receiver gain is set high during the pre-scan producing insufficient digital sampling of the echo and representing low signals incorrectly on the image. T1 sagittal imaging of the cervical spine is a common site for this artifact. Truncations occur in the phase direction only (Fig. 5). Increasing the number of phase encoding steps may compensate for this artifact.

Chemical shift artifact: Chemical shift artifacts are caused by different resonance frequencies of hydrogen in lipid and in water; in which misregistration of fat and water protons causes a signal void between areas of fat and water. This event occurs in high field strength where at 0.5 T or lower chemical shift is insignificant and compensation is usually not necessary.

Broadening the receiver bandwidth and the smallest possible FOV reduces chemical artifact. However, a wider bandwidth will reduce ANR as well. If the bandwidth is reduced, the best SNR is obtained using chemical saturation to saturate the signal from either fat or water (Fig. 6).

Zebra artifact: It occurs when patients touch the coil, or as a result of phase wrap (Fig. 7). Making sure the patient is not touching the receive coil and using the no-wrap option may prevent this problem.

Author:
Abed Al Nasser Assi MD
Address: Department of Medical Imaging, Arab American University, Jenin, Palestine.
Tel:+9724-520697
Fax:+9724-510886
Email: assiabed@hotmail.com

References

1. Bernstein MA, Huston J 3rd, Ward HA. Imaging artifacts at 3.0T. J Magn Reson Imaging 2006;24(4):735-46.
2. Dietrich O, Reiser MF, Schoenberg SO. Artifacts in 3-T MRI: physical background and reduction strategies. Eur J Radiol 2008;65(1):29-35.
3. Haacke EM, Clayton JA, Lampman DA, Linga NA. Artifacts in two-dimensional Fourier transform imaging. Program of the Annual Meeting of the Society of Magnetic Resonance in Medicine, New York, August 1984:288-9.
4. Starčuk Z, Bartušek K, Hubálková H, Bachorec T, Starčuková J, Krupa P. Evaluation of MRI artifacts caused by metallic dental implants and classification of the dental materials in use. Meas Sci Rev 2006;6(2):24-7.Available from http://www.measurement.sk/2006/S2/Starcuk.pdf. Accessed May 20, 2009.
5. Brown MA, Semelka.RC. MRI basic principle and application. 3th ed. New Jersey: Wiley-Liss; 2003. p. 117.
6. Westbrook C, Kait C. MRI in practice. 2nd ed. Oxford: Backwell; 1998. p. 164.
7. Blink.E. An easy introduction basic MRI physics. Available at: http://www.mri-physics.com. Accessed May 25, 2009.
8. Pusey E, Brown RKJ, Lufkin A, Solomon M, Hanafee W. Artifacts in MA imaging: mechanisms and clinical significance. Radiology 1985;1 57:296.