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

Magnetic Resonance Imaging

First Semester

Lecture 1,2: MRI Terms

2024/2025

Introduction:

MRI technicians need to know MRI terms definitions for several reasons, including:

Understanding medical terminology: MRI technicians need to have a basic understanding of medical terminology to communicate effectively with physicians and other healthcare professionals Mastering MRI procedures: MRI technicians need to understand and master MRI procedures, including the terminology used in MRI imaging, to perform their job effectively.

Ensuring MRI safety: MRI technicians need to have sound knowledge of the physical principles of the MRI scanner and understand the associated safety risks to avoid adverse events from occurring.

Encountering MRI terminology: MRI technicians are likely to encounter MRI terminology in the course of their work, and they need to be familiar with the terminology to perform their job effectively.

1. **Alignment:** - When nuclei are placed in an external magnetic field their magnetic moments line up with the magnetic field flux lines. (fig.1)
2. **Ampere's law:** - Determines the magnitude and direction of the magnetic field due to a current, if you point your right-hand thumb along the direction of the current, then the magnetic field points along the direction of the curled figures. (fig.2)
3. **Anti-parallel alignment:** - Describes the alignment of the magnetic moments in the opposite direction of main magnetic field Bo.
4. **Axial:** - A plane, slice, or section made by cutting the body or part of it at right angles to the long axis of the body. (fig.3)

5. **B or Bo:** - A conventional symbol for the constant magnetic field produced by the large magnet in the MR scanner.
6. **Bipolar:** - Describes a magnet with two poles, north and south. (fig.4(
7. **Black blood imaging:** acquisitions in which blood vessels are black.
8. **Blood oxygen level dependent (BOLD):** a functional MRI technique that uses the differences in magnetic susceptibility between oxyhemoglobin and deoxyhemoglobin to image areas of activated cerebral cortex. (fig.5)

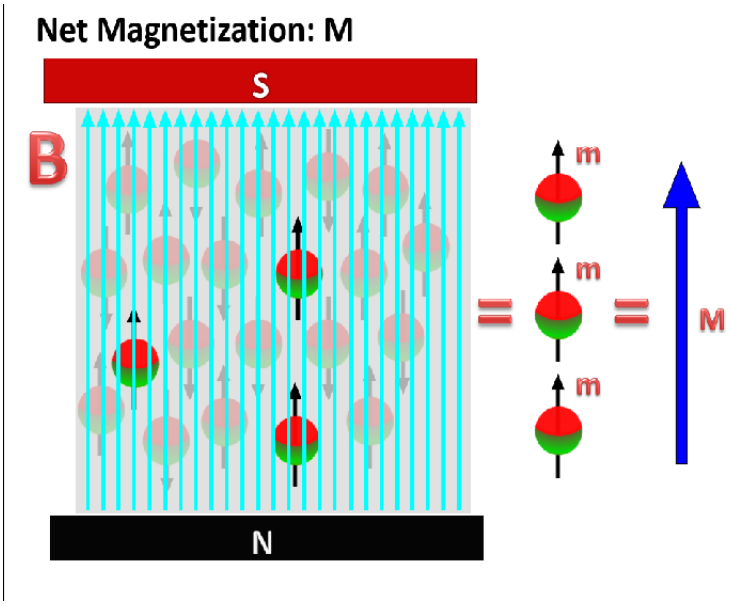

Fig.1: Alignment of protons with the external magnetic field.

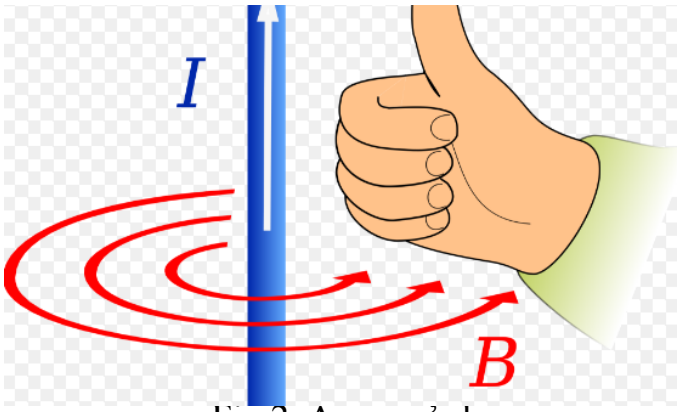

Fig.2: Ampere's law.

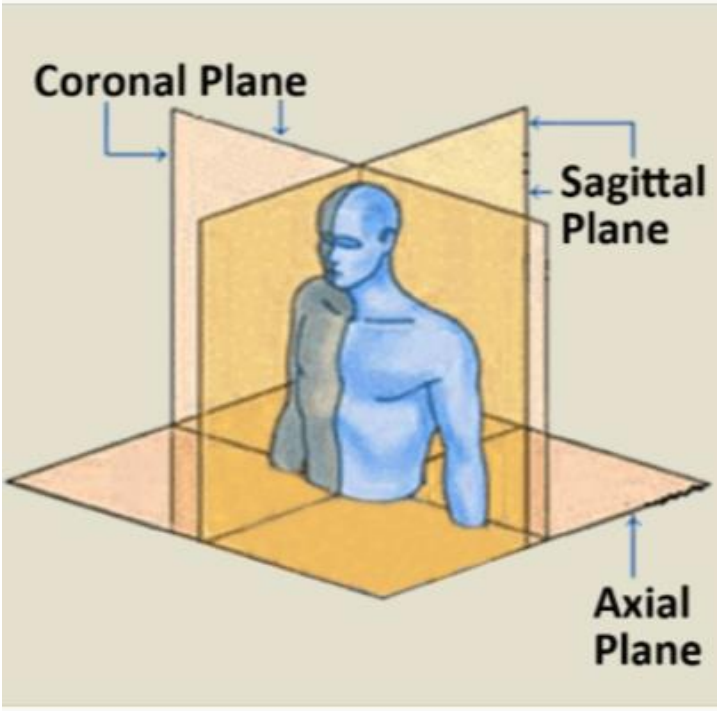

Fig.3: Axial, sagittal, and coronal plane.

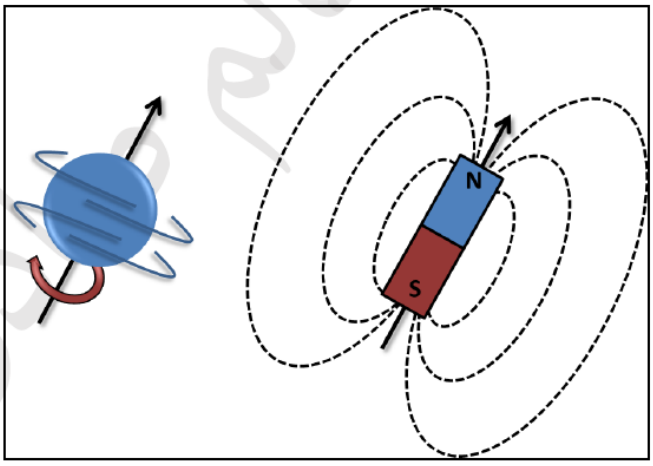

Fig.4: Bipolar (a magnet with two poles)

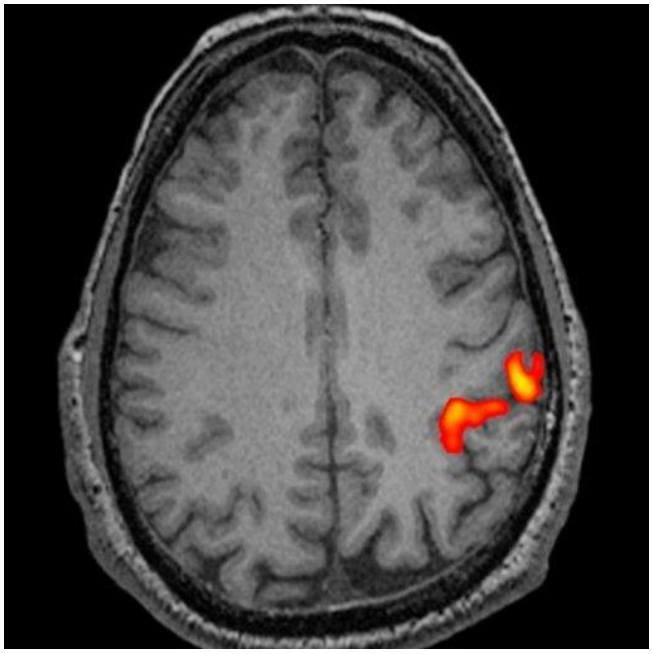

Fig.5: BOLD imaging

9. **Bright blood imaging:** acquisitions in which blood vessels are bright.
10. **Contrast reversal:** an image phenomenon where the darks become bright, and the brights become dark. This is usually most prevalent in sequences utilizing an extended TR.
11. **Claustrophobia:** - A psychological reaction to being confined in a relatively small area.
12. **Coronal:** - A plane, slice, or section made by cutting across the body from side to side and therefore parallel to the coronal suture of the skull.
13. **Cryogen bath:** area around the coils of wire in which cryogens are placed.
14. **Cryogens substances:** used to supercool the coils of wire in a superconducting magnet.
15. **Diffusion-weighted image:** Imaging techniques designed to weight the measured MRI signal by the amount of diffusion (random thermal motion) of water molecules in the selected voxels.

16. **Electromagnet:** - A type of magnet that utilizes coils of wire, typically wound on an iron core, so that as current flows through the coil it becomes magnetized.
17. **Equilibrium: -** A state of balance that exists between two opposing forces or divergent forms of influence.
18. **Excitation:** - Delivering (inducing, transferring) energy into the "spinning" nuclei via radio-frequency pulses, which puts the nuclei into a higher energy state. By producing a net transverse magnetization, an MRI system can observe a response from the excited system.
19. **Echo spacing:** spacing between each echo in FSE.
20. **Echo train:** series of 180° rephasing pulse and echoes in a fast spin echo pulse sequence.
21. **Echo train length (ETL):** the number of 180° RF pulses and or turbo factor resultant echoes in FSE. (fig.6)
22. **Frequency:** The number of cycles or repetitions of any periodic wave or process per unit time. In electromagnetic radiation, it is usually expressed in units of hertz (Hz), where 1 Hz=1 cycle per second.
23. **Free Induction Decay (FID):** loss of signal due to relaxation; if transverse magnetization of the spins is produced, e.g., by a 90É RF pulse, a transient MR signal at the Larmor frequency results that decays toward zero with a characteristic time constant of T2*. This decaying signal is the FID. (fig.7)
24. **Fringe field:** stray magnetic field outside the bore of the magnet.
25. 25- Frequency encoding: the process of locating an MR signal in one dimension by applying a magnetic field gradient along that dimension during the period when the signal is being received.

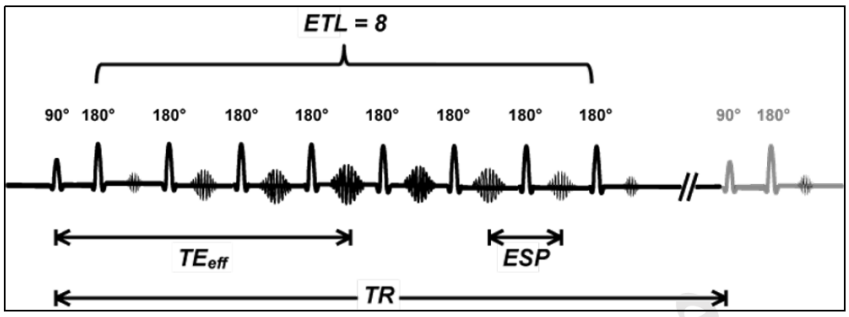

Fig 6: Echo train, echo spacing, and echo train length in FSE.

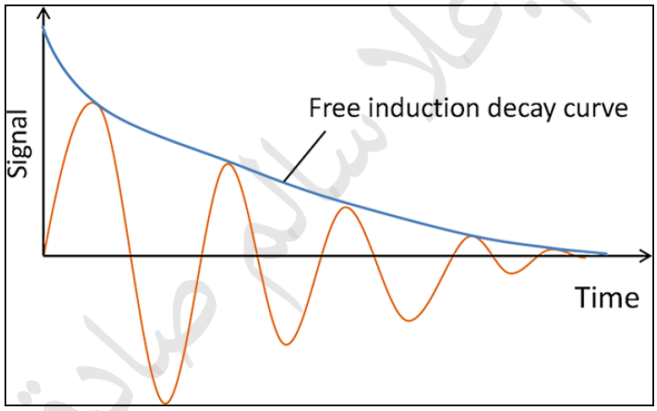

Fig 7: Free induction decay curve

26. **Gyromagnetic ratio:** - A constant for any given nucleus that relates the nuclear MR frequency and the strength of external magnetic field. It represents the ratio of the magnetic moment (field strength) to the angular momentum (frequency) of a particle. The value of the gyromagnetic ratio for hydrogen is 4.258Hz/Gauss (42.58 MHz/Tesla).

27. **Gadolinium (Gd):** gadolinium is a non-toxic paramagnetic contrast enhancement agent utilized in MR imaging. When injected during the scan, gadolinium will tend to change signal intensities by shortening T1 in its surroundings.

28. **Gradient coils:** three paired orthogonal current-carrying coils located within the magnet which are designed to produce desired gradient magnetic fields which collectively and sequentially are superimposed on the main magnetic field (Bo) so that selective spatial excitation of the imaging volume can occur. Gradients are also used to apply reversal pulses in some fast-imaging techniques.

Introduction:

MRI technicians need to know MRI terms to communicate effectively with healthcare professionals, understand and master MRI procedures, ensure MRI safety, and perform their job effectively. MRI terms can be found in MRI reports, glossaries, and educational resources. It is important for MRI technicians to keep up-to-date with the latest MRI technology and terminology to provide the best possible care for their patients and parameters.

29. **Hertz:** - The standard unit of frequency equal to 1 cycle per second. The larger unit megahertz (MHz=1000,000 Hz).
30. **Homogeneity:** - Uniformity of the main magnetic field.
31. **Hydrogen density:** - The concentration of Hydrogen atoms in water molecules or in some groups of fat molecules within tissue. Initial MR signal amplitudes are directly related to H+ density in the tissue being imaged.
32. **Inhomogeneity:** - Lack of homogeneity or uniformity in the main magnetic field.

33. **Image data acquisition time:** the time required to gather a complete set of image data.
34. **Image reconstruction:** the mathematical process of converting the composite signals obtained during the data acquisition phase into an image.
35. **Larmor equation:** - An equation that states that the frequency of precession of the nuclear magnetic moment is directly proportional to the product of magnetic field strength (Bo) and the gyromagnetic ratio. W=gBo.
36. **Longitudinal magnetization:** the component of the net magnetization vector in the direction of the static magnetic field. After RF excitation, this vector returns to its equilibrium value at a rate characterized by the time constant T1.
37. **Longitudinal relaxation time:** the time constant, T1, which determines the rate at which excited protons return to equilibrium within the lattice. A measure of the time taken for spinning protons to re-align with the external magnetic field. The magnetization will grow after excitation from zero to a value of about 63% of its final value in a time of T1. (fig 8)
38. **Magnetic resonance:** - The absorption or emission of energy by atomic nuclei in an external magnetic field after the application of RF excitation pulses using frequencies which satisfy the conditions of the Larmor equation.
39. **Net magnetization:** - A vector which represents the sum of all of the contributions of the magnetic moments within the magnetic field; the magnitude and direction of the magnetization resulting from this collection of atomic nuclei.

40. **Oblique:** - A plane or section not perpendicular to the xyz coordinate system, such as the long and short axis views of the heart. (fig 9)
41. **Orthogonal:** - A plane or section perpendicular to the xyz coordinate system.
42. **Permanent magnet:** - Magnets that retain their magnetism.
43. **Precession:** - The secondary spin of magnetic moments around Bo. (fig 10)
44. **Proton density:** - The number of protons in a unit volume of tissue.
45. **Paramagnetic substance:** a substance with weak magnetic properties due to its unpaired electrons.
46. **Pixel:** acronym for a picture element, the smallest discrete two-dimensional part of a digital image display. (fig 11)
47. **Relaxation time:** after excitation the spins will tend to return to their equilibrium distribution in which there is no transverse magnetization and the longitudinal magnetization is at its maximum value and oriented in the direction of the static magnetic field. After excitation the transverse magnetization decays toward zero with a characteristic time constant T2, and the longitudinal magnetization returns toward equilibrium with a characteristic time constant T1. (fig 12)
48. **Repetition time (TR):** the amount of time that exists between successive pulse sequences applied to the same slice. It is delineated by initiating the first RF pulse of the sequence then repeating the same RF pulse at a time t. Variations in the value of TR have an important effect on the control of image contrast characteristics. Short values of TR (< 1000 ms) are common in images exhibiting T1 contrast, and long values of TR (> 1500 ms) are common in images exhibiting T2 contrast.

49. **Readout gradient:** the frequency encoding gradient. (fig 13)
50. **Shim coils:** coils positioned near the main magnetic field that carry a relatively small current that is used to provide localized auxiliary magnetic fields in order to improve field homogeneity.
51. **Sampling rate:** rate at which samples are taken during readout.
52. **Shimming:** process whereby the evenness of the magnetic field is optimized. (fig 14)
53. **Voxel volume element;** the element of the three-dimensional space corresponding to a pixel, for a given slice thickness.

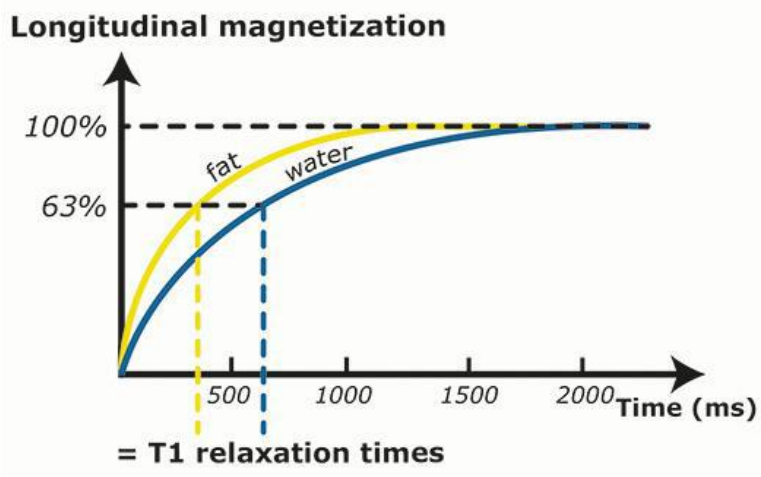

Fig 8: T1 relaxation time

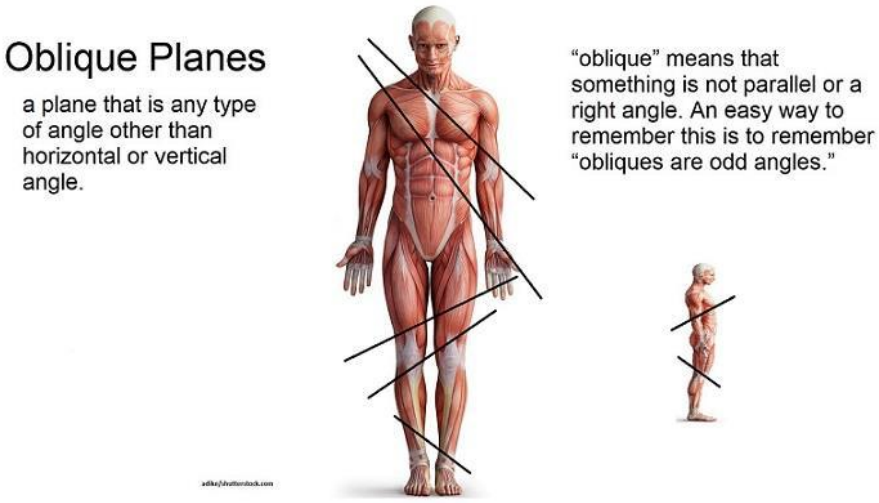

Fig 9: oblique plane

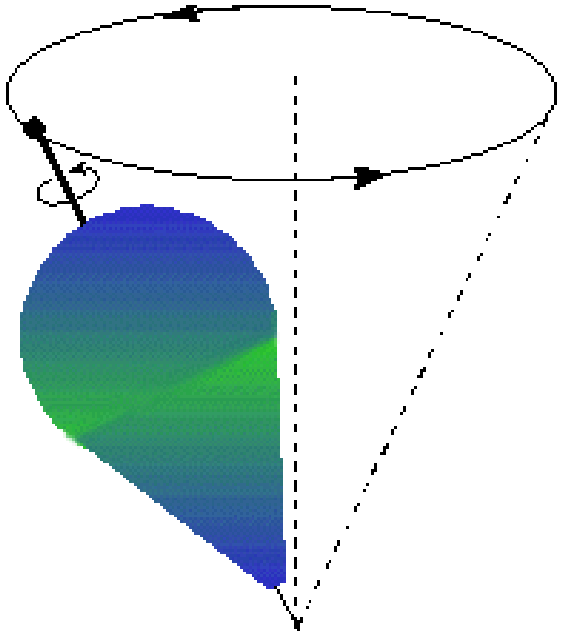

Fig 10: Precession

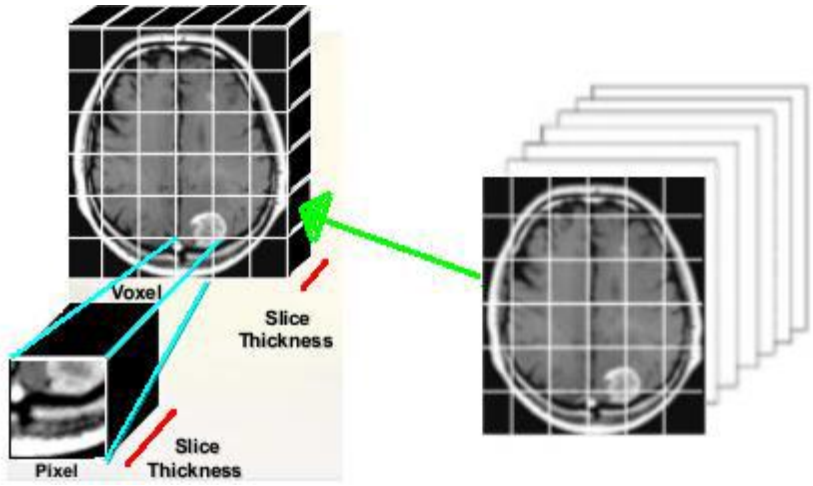

Fig 11: Pixel and voxel

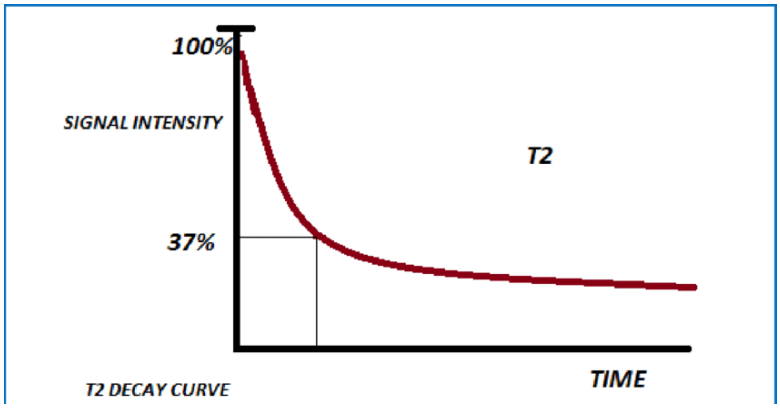

Fig 12: T2 decay curve

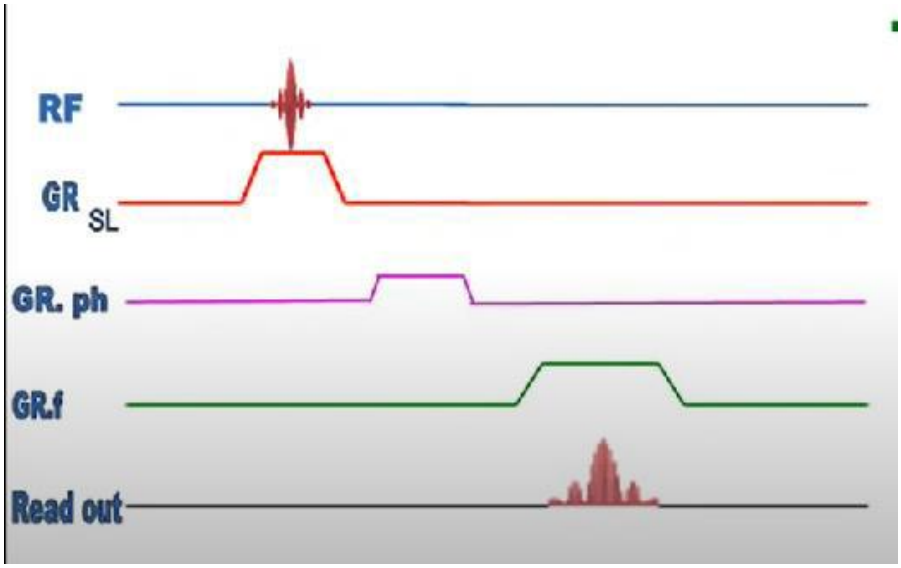

Fig 13: MRI sequence

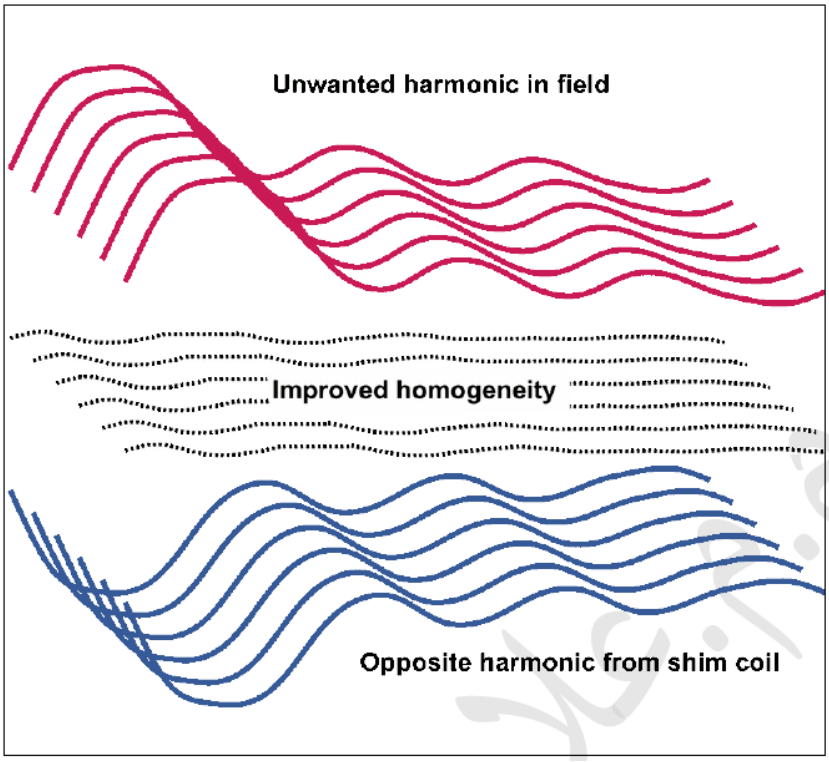

Fig 14: Shimming by shim coil