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Sudan University of Science and Technology

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Evaluation of Magnetic Resonance Imaging Artifact in Medical Imaging Centers in Khartoum State

تقويم تشوهات صور الرنين المغنطيسي في مراكز التصوير الطبي في ولاية الخرطوم

A Thesis Submitted For Partial Fulfillments of the Master Degree in Medical Diagnostic Imaging

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الآية

﴿وَيَسْأَلُونَكَ عَنِ الرُّوحِ قُلِ الرُّوحُ مِنْ أَمْرِ رَبِّي وَمَا أُوتِيتُمْ مِنَ الْعِلْمِ إِلَّا قَلِيلًا﴾

صدق الله العظيم

سورة الاسراء الاية(85)

Dedication

To My Precious Mother Who Support & Loved Me.

To My Dad Without You I Couldn’t Do This

To My Sister & Brothers Who Helped Me

Acknowledgments

I am using this opportunity to express my gratitude to everyone who supported me throughout the research . I am thankful for their aspiring guidance, invaluably constructive criticism and friendly advice during the research work. I am sincerely grateful to them for sharing their truthful and illuminating views on a number of issues related to the research .

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Abstract

The aim of this study was to detect the MRI artifacts in medical imaging center in Khartoum and detecting their Causes and remedy made by the technologist to provide information that well serve as useful data base for MRI artifact . Using data sheet filling out by technologist observation to collecting the data along 3 month on Dar Alelaj Specialized Hospital . The result showed the motion artifact was the most dominant type of artifact which is 54% ,then software slice overlap and tissue heterogeneous were had the same percentage (16%) for each ,the MR hardware 8% and the lowest recurrent artifact observed was Fourier transform nyquist sampling by (6%). Through my observation for most common Artifacts in the magnetic resonance imaging centers in Khartoum state we found most common artifacts that is of patient movement (motion Artifacts) due to differentials reasons e.g.: unconscious patient ,lack cooperation and instruction , MR software slice overlap appear from not accurate planning , MR hardware & room shielding caused by some element of coil not working , and Fourier transform & nyquist sampling. The study conclude that the patient motion artifact is the most common .the study recommended that the patient should be instructed before exam and preventive maintenance for MR coils must be keep on .

مستخلص البحث

كان الهدف من هذه الدراسة هو اكتشاف تشوهات صور الرنين المغناطيسي في مراكز التصوير الطبي في ولاية الخرطوم والكشف عن أسبابها واالتصحيح الذي قدمها اختصاصي التقني ، لتوفير المعلومات التي تعمل بشكل جيد كقاعدة بيانات مفيدة لتشوهات صور الرنين المغناطيسي. تم استخدام ورقة البيانات وملئها من خلال مراقبة اختصاصي التقني لجمع البيانات على مدار ثلاثة اشهر في مستشقي دار العلاج التخصصي. وأظهرت النتيجة أن تشوهات صور الرنين الناتجة عن الحركة كانت النوع الأكثر انتشارًا تبلغ54٪ ، وكانت شريحة البرامج المتراكبة والانسجة غير المتجانسة لها نفس النسبة (16٪) لكل منهما، وكانت اجهزة الرنيين المغناطيسي(8٪) ، واقل تشوه متكرر لوحظ فوريية تحويل واخذ العينة بنسبة (6٪) من خلال ملاحظتي لمعظم التشوهات الشائعة في مراكز التصوير بالرنين المغنطيسي في ولاية الخرطوم ، وجدنا معظم التشوهات الشائعة التي تتعلق بحركة المريض نتيجة لأسباب مختلفة على سبيل المثال : المريض غير واعي ، نقص التعاون والتوجيه للمريض ، المؤثر الثاني شريحة البرامج المتراكبة تظهرمن التخطيط غير الدقيق ، ثم اجهزة الرنيين المغناطيسي وتدريع الغرفة الناتجة عن ان بعض عناصر الملفات لا تعمل و فوريية تحويل و اخذ العينة من نفس السبب. خلصت الدراسة الي ان مؤثر الحركي الناتج من حركة المريض هي الاكثر شيوعا. اوصت الدراسة بان يتم توجيه المريض قبل الفحص و يجب ان تستمر الصيانة الوقائية لملفات الرنيين المغناطيسي.

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LIST OF ABBREVIATIONS

MRI	Magnetic Resonance Imaging
NMR	Nuclear Magnetic Resonance
FSE	Fast Spin Echo
FOV	Field of View
PERU	Physiological Electro-Cardiography Respiratory Unit
ECG	Electro- Cardiography
RF	Radio Frequency
T	Tesla
SE	Spin Echo
CSF	Cerebro Spinal Fluid
TE	Echo Time
MRA	Magnetic Resonance Angiography
EPI	Echo Planar Imaging
KADC	Khartoum Advance Diagnostic Center
MR	Magnetic Resonance

Chapter one

Introduction

Chapter one

1.1introduction

MRI (an abbreviation of magnetic resonance imaging) is an imaging modality that uses non-ionising radiation to create useful diagnostic images. MRI was initially called nuclear magnetic resonance (NMR) imaging after its early use for chemical analysis. The initial "nuclear" part was dropped about 25 years ago because of fears that people would think there was something radioactive involved, which there is not.(pooley , 2005)

NMR was discovered simultaneously by two physicists, Felix Bloch and Edward Mills Purcell, just after the end of the Second World War. Bloch trained in quantum mechanics and was involved with atomic energy and then radar counter-measures. At the end of the war, he returned to his earlier work in the magnetic moment of the neutron. Purcell was involved with the development of microwave radar during the war then pursued radio waves for the evaluation of molecular and nuclear properties. They received the Nobel Prize in Physics in 1952 for this discovery.(pooley RA ,2005)

MRI, the use of NMR to produce 2D images was accomplished by Paul Lauterbur, imaging water, and Sir Peter Mansfield who imaged the fingers of a research student, Andrew Maudsley in 1976. Maudsley continues to make a significant contribution to the development of MRI today. Raymond Damadian obtained human images a year later in 1977. Lauterbur and Mansfield received the Nobel Prize in Physiology or Medicine in 2003 for their development of MRI. This award was controversial in that the contributions of Damadian to the development of MRI were overlooked by the Nobel Committee.(pooley RA , 2005)

In simple terms, an MRI scanner consists of a large, powerful magnet in which the patient lies. A radio wave antenna is used to send signals to the body and then receive signals back. These returning signals are converted into images by a computer attached to the scanner. Imaging of any part of the body can be obtained in any plane. (pooley RA , 2005)

MRI artifacts are numerous and give an insight into the physics behind each sequence. Some artifacts affect the quality of the MRI exam while others do not affect the diagnostic quality ,but may be confused with pathology

When encountering an unfamiliar artifact, it is useful to systematically examine general features of the artifact to try and understand its general class. These features include:

- type of sequence, e.g. fast spin echo, gradient, volumetric acquisition
- direction of phase and frequency
- fat or fluid attenuation
- presence of anatomy outside the image field
- presence of metallic foreign bodies

Classification of the artifact type may give one an idea about how to try to fix it.The artifacts

Many artifacts have a characteristic appearance and with experience they can be readily identified.(pooley ,2005)

Artifacts are caused by a variety of factors that may be patient-related such as voluntary and physiologic motion, metallic implants or foreign bodies. Finite sampling, k-space encoding, and Fourier transformation may cause aliasing and Gibbs artifact. Characteristics of pulse sequences may cause black boundary, Moiré, and phase-encoding artifacts. Hardware issues may cause central point and RF overflow artifacts.(pooley , 2005)

1.2 statement of the problem

Recently observed recurrence MRI artifacts in medical imaging centers affect on the out com image, technologies and radiologist .

1.3 justification

provide information that well serve as a useful data base for MRI artifact in medical imaging centers .

1.4 Objectives of the study

1.4.1 general objective

To study of the MRI artifacts in medical imaging center in Khartoum .

1.4.2 specific objectives

- to assess the rate of recurrence MRI artifacts in medical imaging center in Khartoum .

- to identify the correction made by the technologist for MRI artifact in medical imaging center in Khartoum.

-to assess of the knowing cause of MRI artifact in medical imaging centers in Khartoum.

-classification MRI artifacts in medical imaging center in khartoum.

Chapter Tow

Literature Review

Chapter Tow

Literature Review

2.1 MRI physics

MRI has strong underpinnings in physics which must be understood before any real sense of 'how it works' is gained.

The process can be broken down into four parts:

1.Preparation

2.Excitation

3.Spatial encoding

4.Signal acquisition (Hashemi et-al, 2010).

2.1.1 Preparation

The patient is placed in a static magnetic field produced by the magnet of the MR scanner. In living tissues there are a lot of hydrogen atoms included in water molecules or in many different other molecules. The proton, the nucleus of Hydrogen, does possess an intrinsic magnetisation called spin. The spin magnetization vector precesses (rotates) around the magnetic field at a frequency called Larmor frequency, which is proportional to the magnetic field intensity. The resulting magnetisation of all protons inside the tissues aligns parallel to the magnetic field. The parallel magnetisation scales with the magnetic field intensity, basically at 3T it will be twice the value obtained at 1.5T. Additional preparation sequences can also be performed to manipulate the magnetisation and so the image contrast, e.g. inversion preparation(Hashemi et-al, 2010).

2.1.2 Excitation

During the image acquisition process, an RF pulse (radio frequency pulse) is emitted from the scanner. When tuned to the Larmor frequency, the RF pulse is at resonance: it creates a phase coherence in the precession of all spins. The duration of the RF pulse is chosen such that it tilts the spin magnetisation perpendicularly to the magnetic field. When a receiving coil (an electrical conductor) is put in the vicinity of the tissue, the transverse magnetisation, that still rotates as the Larmor precession, will generate an electric current in the coil by Faraday induction: this is the nuclear magnetic resonance (NMR) signal. The NMR signal is actually attenuated due to two relaxation processes. The loss of coherence of the spin system attenuates the NMR signal with a time constant called the transverse relaxation time T2. Concurrently, the magnetisation vector slowly relaxes towards its equilibrium orientation that is parallel to the magnetic field: this occurs with a time constant called the spin-lattice T1 relaxation time. The contrast in MR images originates from the fact that different tissues have, in general, different T1 and T2 relaxation times; as this is especially true for soft tissues, it explains the excellent soft tissue contrast of MR images (Hashemi et-al, 2010).

2.1.3 Spatial encoding

Spatial encoding of the MRI signal is accomplished through the use of magnetic field gradients (smaller additional magnetic fields with an intensity that linearly depends on the spatial location): spins form protons in different locations do precess at slightly different rates. The portion of the gradient coils and the associated current that is perpendicular to the main magnetic field cause a force (Lorentz force) on the coils. The gradients are turned on and off very quickly in this process causing them to vibrate and producing the majority of the acoustic noise during a MR image acquisition (Hashemi et-al, 2010).

2.1.4 Signal acquisition

When using magnetic field gradients, the obtained NMR signal contains different frequencies corresponding to the different tissue spin positions and is called the MRI signal. After sampling, the analog MRI signal is digitalised and stored for processing, which consists of a separation of the signal contributions from different spatial locations represented by pixels in the final image. This is achieved by a mathematical operation called Fourier transform (Hashemi et-al, 2010).

2.1.5 Standard exam

Multiple image sets are obtained in the standard exam (which varies from facility to facility). Exam times vary according to the part of the anatomy being studied, pathology expected, and radiologist preferences. Occasionally, a contrast medium may be used to enhance images. Typically, exams are ordered without and with contrast for comparison purposes. Very rarely, and only in certain circumstances are exams ordered with contrast only. After the exam the patient is removed from the scanner and given post-procedure instructions (information about contrast medium if used, sedation if used, and time when to expect a report from the examination) (Hashemi et-al, 2010).

2.2. MRI artifact

MRI artifacts are numerous and give an insight into the physics behind each sequence. Some artifacts affect the quality of the MRI exam while others do not affect the diagnostic quality but may be confused with pathology.

When encountering an unfamiliar artifact, it is useful to systematically examine general features of the artifact to try and understand its general class (Hashemi et-al, 2010).

These features include:

- type of sequence, e.g. fast spin echo, gradient, volumetric acquisition
- direction of phase and frequency
- fat or fluid attenuation
- presence of anatomy outside the image field
- presence of metallic foreign bodies

Classification of the artifact type may give one an idea about how to try to fix it. (Allisy et-al, 2007).

2.3Types of artifacts

Many artifacts have a characteristic appearance and with experience they can be readily identified. (Allisy et-al, 2007).

2.3.1 MRI hardware and room shielding

2.3.1.1 zipper artifact

In MR imaging, zipper artifact refers to a type of MRI artefact where one or more spurious bands of electronic noise extend perpendicular to the frequency encode direction and is present in all images of a series.
There are various causes for zipper artifacts in images. Most of them are related to hardware or software problems beyond the radiologist's immediate control. (Anne, 2011).
The zipper artifacts that can be controlled easily are those that occur when the door is open during acquisition of images due to RF entering the scanning room from electronic equipment (e.g. mobile devices or aircraft) and are being picked by the receiver chain of imaging sub-systems. RF from some radio transmitters will cause zipper artifacts that are oriented perpendicular to the frequency axis of your image. Frequently there is more than one artifact line on an image from this cause corresponding to different radio frequencies.

Other equipment and software problems can cause zippers in either axis. (Anne, 2011).

Remedy

make sure the MR scanner room-door is shut during imaging remove all electronic devices from the patient prior to imaging if the artifact persists despite all nearby electronic equipment being turned off, it is possible that the RF shielding is compromised .

this usually occurs at the contacts between the door and the jam and may need to be cleaned or repaired .

the penetration panel where the cables enter the room is another site to be checked. (Anne, 2011).

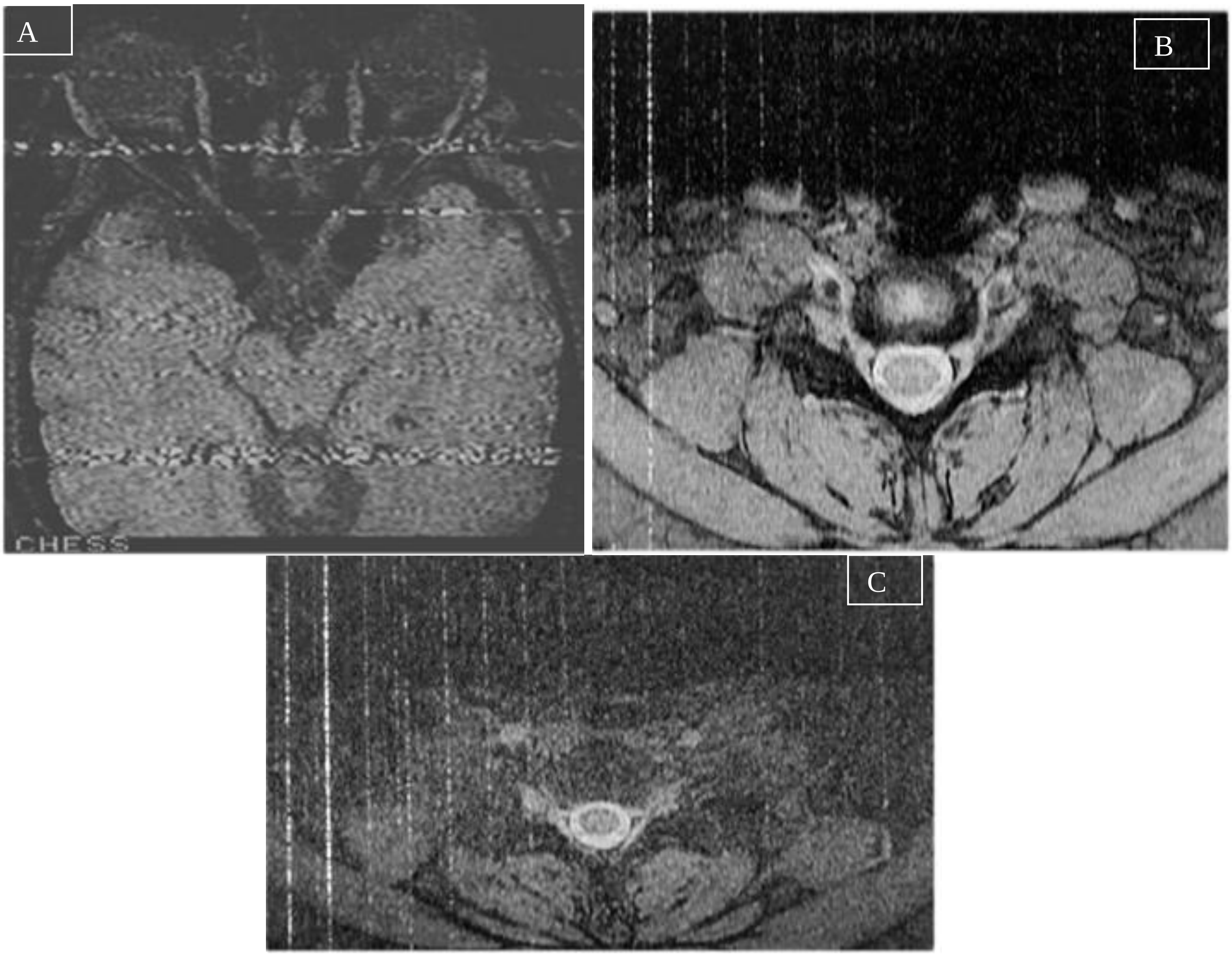

Figure 2.1 show zipper artifact(Anne, 2011).

2.3.1.2 herringbone artifact

Herringbone artifact, also called as crisscross artifact or corduroy artifact, is an MRI artifact, it appears as a fabric of herring bone. The artefact is scattered all over the image in a single slice or multiple slices. (Anne, 2011).

Causes

- electromagnetic spikes by gradient coils
- fluctuating power supply
- RF pulse discrepancieszebra stripes

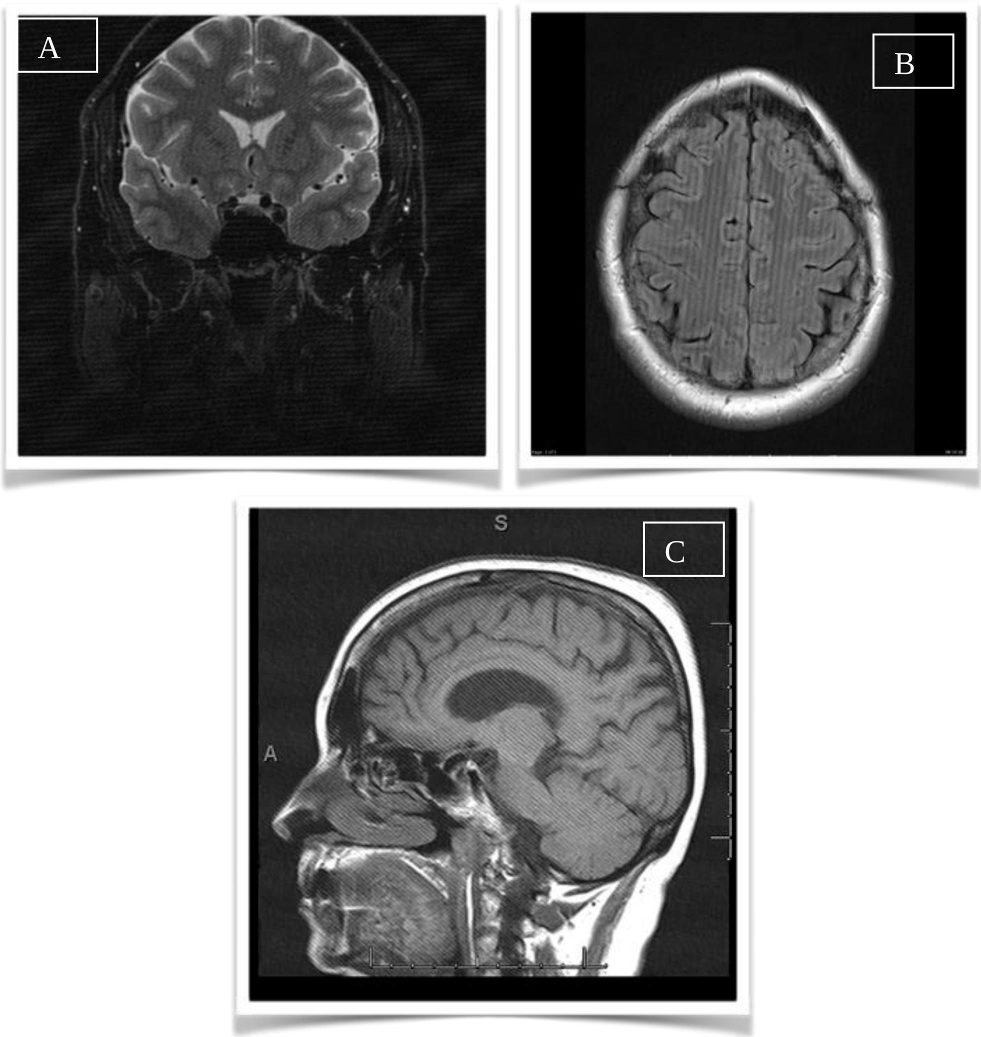

figure 2.2 show herringbone artifact (Anne, 2011).

2.3.1.3 Moiré fringes

Moiré fringes are an interference pattern most commonly seen when acquiring gradient echo images using the body coil.

Because of lack of perfect homogeneity of the main magnetic field from one side of the body to the other, aliasing of one side of the body to the other results in superimposition of signals of different phases that alternatively add and cancel. This causes the banding appearance similar to the effect of looking through two screen windows. (Anne, 2011).

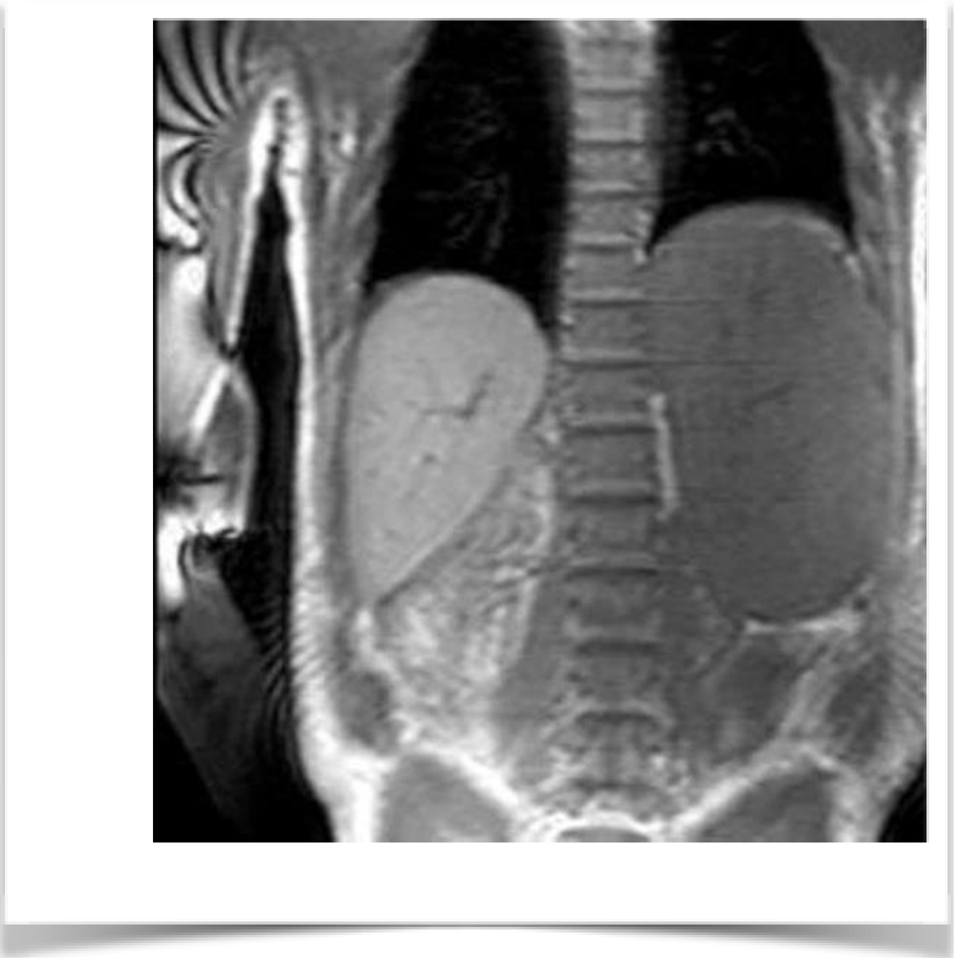

figure 2.3 show Moiré artifact

Gradient Echo (Moire Fringes MRI artifact) (Anne, 2011).

2.3.1.4 Zebra stripes/artifacts

Zebra stripes/artifacts appear as alternating bright and dark bands in a MRI image. The term has been used to describe several different kind of artifacts causing some confusion. (Anne, 2011).

Artifacts that have been described as a zebra artifact include the following:

- Moire fringes
- Zero-fill artifact
- Spike in k-space
- Zebra stripes have been described associated with susceptibility artifacts.

In CT there is also a zebra artifact from 3D reconstructions and a zebra sign from hemorrhage in the cerebellar sulci.

It therefore seems prudent to use "zebra" with a term like "stripes" rather than "artifacts".(Anne, 2011).

2.3.1.5 central point artifact

The central point artifact is a focal dot of increased signal in the centre of an image. It is caused by a constant offset of the DC voltage in the receiver. After Fourier transformation, this constant offset gives the bright dot in the centre of the image as shown in the diagram.

The axial MRI image of the head shows a central point artifact projecting in the pons in the centre of the image. (Anne, 2011).

Correction and prevention

- repeating the sequence may get rid of the artifact.
- maintain a constant temperature in scanner and equipment room for receiver amplifiers.

- software to estimate DC offset and adjust the data in k-space.
- call service engineer for recalibration(Anne, 2011).

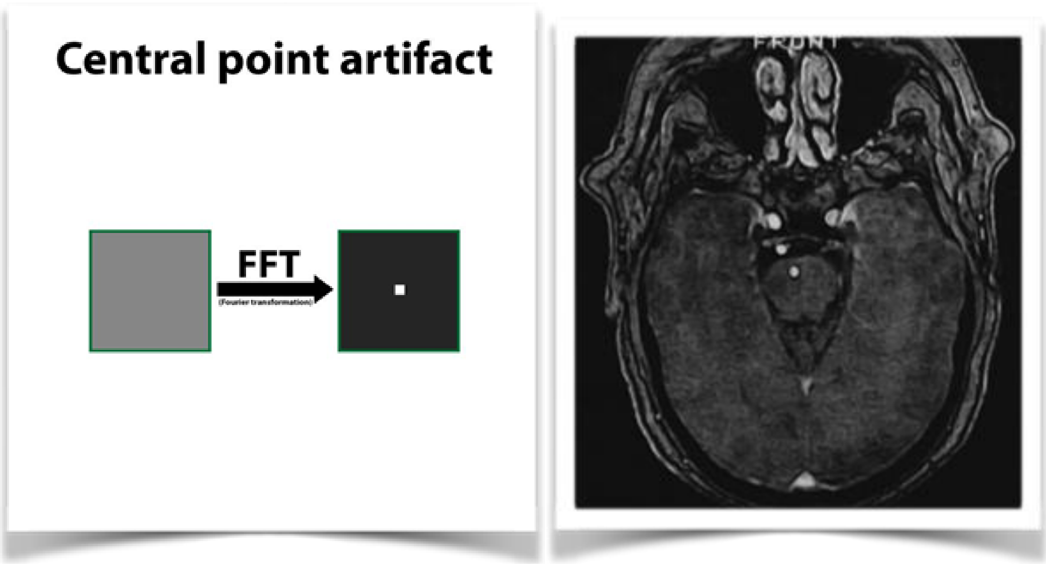

figure 2.4 show central point artifact(Anne, 2011).

2.3.1.6 RF overflow artifact

RF overflow artefact cause a nonuniform, washed-out appearance to an image. This artifact occurs when the signal received by the scanner from the patient is too intense to be accurately digitized by the analog-to-digital converter. Autoprescanning usually adjusts the receiver gain to prevent this from occurring but if the artifact still occurs, the receiver gain can be decreased manually 1. Post-processing methods also exist but may be time consuming . (Westbrook et-al, 2011).

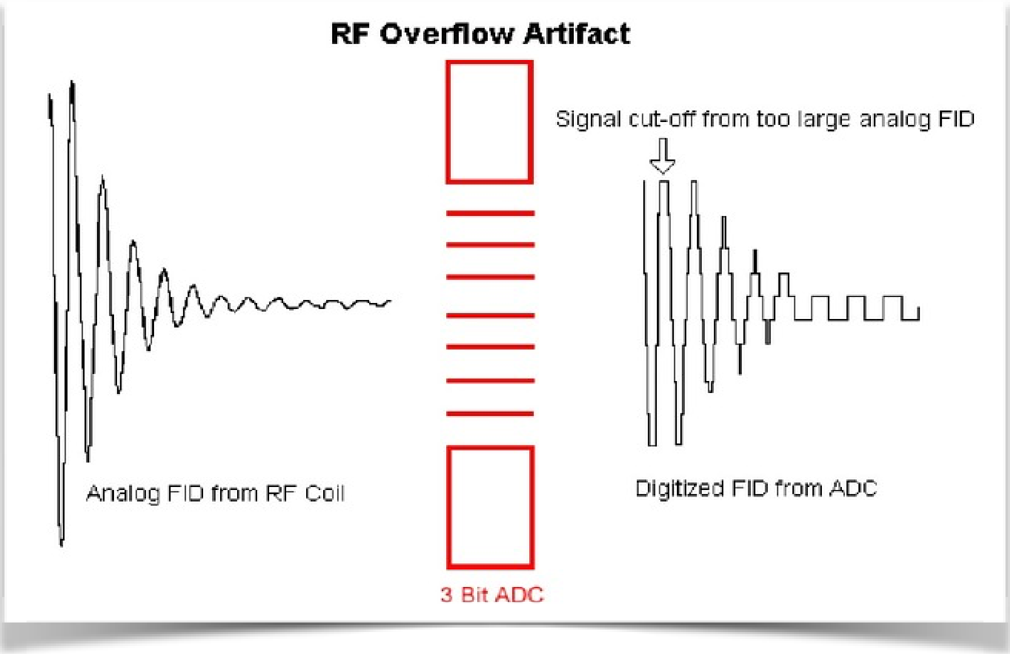

figure 2.5 show   RF overflow artifact

RF overflow artifact diagram(Westbrook et-al, 2011).

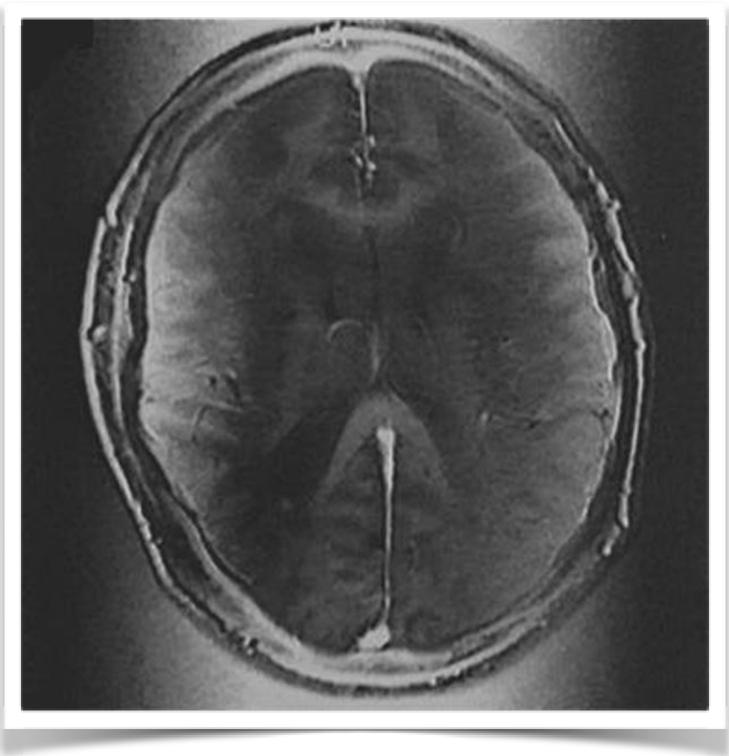

Figure2.6 show over flow MRI artifact(Westbrook et-al, 2011).

2.3.1.7 shading artifact

Shading artifact in MRI refers to loss of signal intensity in one part of the image, leading to dark shading in this portion of the image. (Westbrook et-al, 2011).

Causes

- uneven excitation of nuclei within the field; due to RF pulses applied at flip angles other than 90 and 180 degrees
- abnormal loading of coil or coupling of coil at a point (as with a large patient whom touches one side of the coil)
- inhomogeneity in the magnetic field
- overflow of analog to digital converter.

Axis

- frequency encoding
- phase encoding

Remedy

- load the coil correctly
- use the proper size coil for patient size and the examined part
- Prevent the patient touching the coil (you can use foam pads between patient and coil)
- shimming to reduce inhomogeneity of the magnetic field
- use the proper scanning parameters to set proper amplitude of applied RF pulses (less amplification to avoid analog to digital converter over flow) (Westbrook et-al, 2011).

2.3.1.8 aliasing artifact

Aliasing in MRI, also known as wrap-around, is a frequently encountered MRI artifact that occurs when the field of view (FOV) is smaller than the body part being imaged. The part of the body that lies beyond the edge of the FOV is projected onto the other side of the image. (Westbrook et-al, 2011).

This can be corrected, if necessary, by oversampling the data. In the frequency direction, this is accomplished by sampling the signal twice as fast. In the phase direction, the number of phase-encoding steps must be increased with a longer study as a result. However, if the FOV and matrix size (phase-encoding steps) are increased and simultaneously number of excitations (or number of signal averages) reduced to half, the imaging time can be kept constant with correction of aliasing. (Westbrook et-al, 2011).

Case 1 demonstrates axial T2-weighted images of the brain that demonstrates aliasing. The first image shows wrap-around with the back of the head projected over the front because the phase-encoded direction is anterior-posterior and the FOV is too small. The second image has the phase and frequency directions reversed resulting in absence of the aliasing artifact. Oversampling was used in the frequency direction to eliminate the aliasing. (Westbrook et-al, 2011).

Remedy

Aliasing in MRI can be compensated for by:

- enlarging the field of view (FOV)
- using pre-saturation bands on areas outside the FOV
- anti-aliasing software
- switching the phase and frequency directions
- use a surface coil to reduce the signal outside of the area of interest.

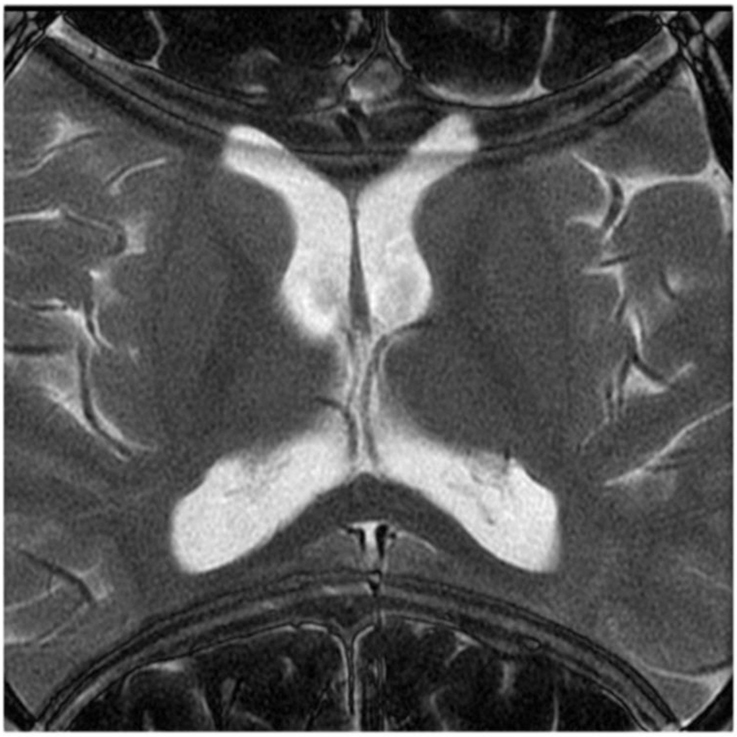

figure 2.7 show aliasing artifact

T2 (aliasing artifact) (Westbrook et-al, 2011).

2.3.1.9 wrap around artifact

liasing in MRI, also known as wrap-around, is a frequently encountered MRI artifact that occurs when the field of view (FOV) is smaller than the body part being imaged. The part of the body that lies beyond the edge of the FOV is projected onto the other side of the image. (Westbrook et-al, 2011).

2.3.2 MRI software

2.3.2.1 slice overlap Artifact

The slice-overlap artefact, also known as cross-talk artefact, is a name given to the loss of signal seen in an image from a multi-angle, multi-slice acquisition, as is obtained commonly in the lumbar spine. It should not be confused with cross excitation which although similar in causation, is not due to angled images. (Westbrook et-al, 2011).

If the slices obtained at different disk spaces are not parallel, then the slices may overlap. If two levels are done at the same time, e.g., L4-5 and L5-S1, then the level acquired second will include spins that have already been saturated. This causes a band of signal loss crossing horizontally in your image, usually worst posteriorly.The dark horizontal bands in the bottom of the following axial image through the lumbar spine demonstrates this artifact.

As long as the saturated area stays posterior to the spinal canal it causes no harm. (McRobbie et-al, 2007).

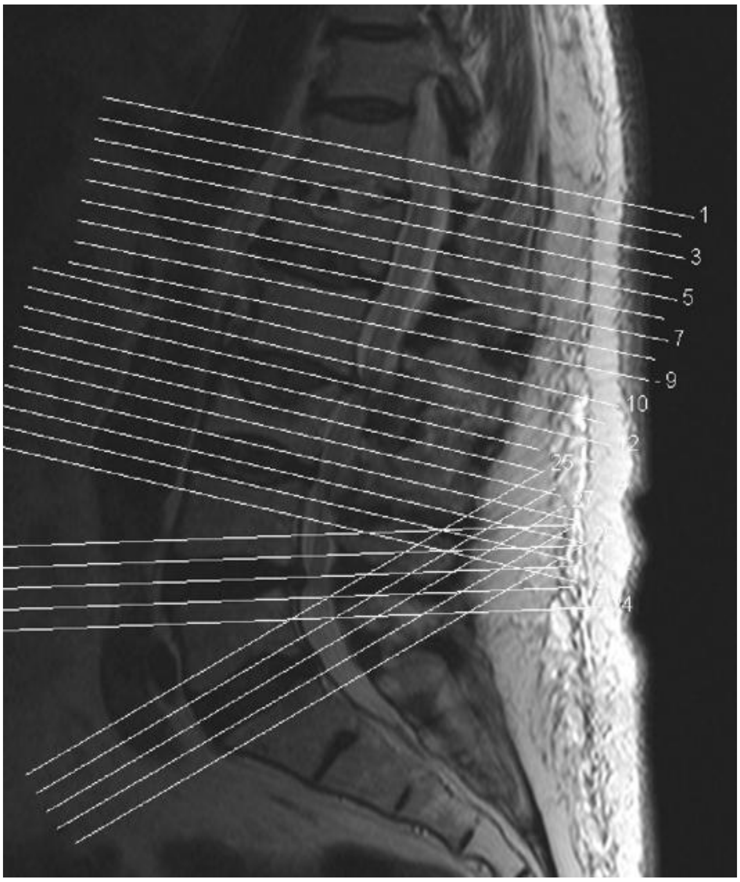

figure 2.8 show 1slice overlap Artifact(McRobbie et-al, 2007).

2.3.2.2 cross-excitation artifact

Cross-excitation artifact is a type of MRI artifact and refers to the loss of signal within a slice due to pre-excitation from RF pulse meant for an adjacent slice. (McRobbie et-al, 2007).

The frequency profile of the RF pulse is imperfect; this means that during slice selection there is some degree of excitation of the adjacent slices as well. If that adjacent slice is imaged during the same TR (i.e., multi-slice imaging) or soon after (i.e., imaging without leaving a gap), it will be partially saturated, to begin with, and the resulting signal will be reduced. This phenomenon is more conspicuous in inversion recovery (180°) sequences. (McRobbie et-al, 2007).

Remedy

- leaving a minimum gap of 1/3 slice thickness when imaging contiguous slices
- interleaving between slices
- employing 3D imaging if volume imaging is required
- using optimized pulse sequences that have a time penalty of a higher minimum TE and reduced number of slices for a given TR(McRobbie et-al, 2007).

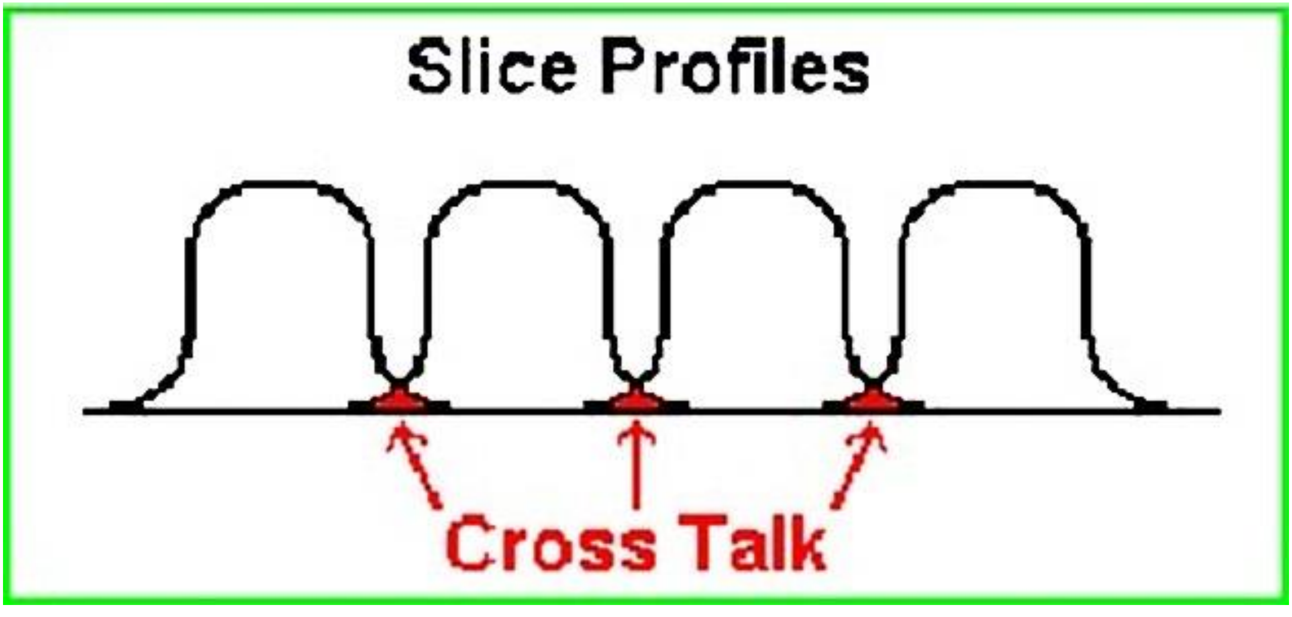

figure 2.9 show cross-excitation artifact(McRobbie et-al, 2007).

2.3.2.3 Fat-water swapping

Fat-water swapping artifact is seen in a significant proportion of fat/water suppressed sequences using the Dixon method. The artifact follows a computational error in areas of field inhomogeneity resulting in incorrectly determining whether a voxel contains water or fat. (McRobbie et-al, 2007).

The images have geographic regions of inappropriate suppression with sharp margins. It can be seen anywhere but is most striking when a whole solid organ appears black on suppressed images. (Gary, 2006).

2.3.3 Patient and physiologic motion

2.3.3.1Phase-encoded motion artifact

Phase-encoded motion artifact is one of many MRI artifacts occurring as a result of tissue/fluid moving during the scan. It manifests as ghosting in the direction of phase-encoding, usually in the direction of the short axis of the image (i.e left to right on axial or coronal brains, and anterior to posterior on axial abdomen). (Harvey et-al, 2007).

These artifacts may be seen from arterial pulsations, swallowing, breathing, peristalsis, and physical movement of a patient. When projected over anatomy it can mimic pathology, and needs to be recognised. Motion that is random such as the patient moving produces a smear in the phase direction. Periodic motion, such as respiratory or cardiac/vascular pulsation, produces discrete, well-defined ghosts. The spacing between these ghosts is related to the repetition time (TR) and the frequency of the motion.

Motion artifacts can be distinguished from Gibbs or truncation artifacts because they extend across the entire field of view (FOV), unlike truncation artifacts that diminish quickly away from the boundary causing them. (Gary, 2006).

Ways of identifying phase artifact include:

identifying known moving/flowing structures and noting that the artifact is in line with them (horizontal or vertical depending on phase-encoding orientation) matching shape of ghost to that of flowing vessel (e.g. round pseudolesion due to aorta ghost) wide windowing to see repetitive ghost beyond confines of anatomy they can be distinguished from Gibbs or truncation artifacts because they extend across the entire field of view, unlike truncation artifacts that diminish quickly away from the boundary causing them(McRobbie et-al, 2007).

Remedy

Solutions to phase mismapping include:

- cardiac/respiratory gating
- spatial presaturation bands placed over moving tissues (e.g. over the anterior neck in sagittal cervical spines)
- spatial presaturation bands placed outside the FOV, especially before the entry or after the exit slice for reducing ghosting from vascular flow: arterial and venous
- scanning prone to reduce abdominal excursion
- switching phase and frequency directions
- increasing the number of signal averages
- shorten the scan time when motion is from patient movement(Gary, 2006).

2.3.3.2 Entry slice phenomenon

Entry slice phenomenon occurs when unsaturated spins in blood first enter into a slice or slices. It is characterised by the bright signal in a blood vessel (artery or vein) at the first slice that the vessel enters. Usually, the signal is seen on more than one slice, fading with distance. This mechanism is used in a positive fashion to generate flight MR angiograms. (Morelli et-al, 2011).

This artefact has been confused with thrombosis with disastrous results. The characteristic location and if necessary, the use of gradient echo flow techniques can be used to differentiate entry slice artefacts from occlusions.

Spatial saturation bands place before the first slice and after the last can be used to eliminate this artefact.

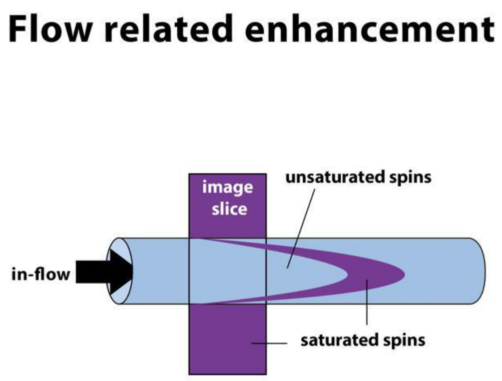

figure 2.10 show flow void(Harvey et-al, 2007).

2.3.3.3 Flow void

Flow voids refer to a signal loss occurring with blood and other fluids, like CSF or urine, moving at sufficient velocity relative to the MRI apparatus. It is a combination of time-of-flight and spin-phase effects usually seen in spin echo techniques (such as T1 and T2-weighted images) 2. (Morelli et-al, 2011).

2.3.3.3.1 Physics

Protons in flowing fluid, such as arterial blood, move out of the plane of imaging in the time between the absorption of the energy of the radio wave pulse and the detection of its release, producing no signal 1-3.

The amount of signal void is related to the velocity of the proton, the slice thickness, the time of echo (TE), and the course of the vessel 1.

A different time-of-flight phenomenon occurs in flow-compensated gradient-echo sequences resulting in flow-related enhancement (time-of-flight angiography). (Harvey et-al, 2007).

2.3.3.3.2 Practical points

flow void is synonymous with vascular patency, representing a normal flow-related signal loss in vessels that contain vigorously flowing blood sequences with long TE (such as T2 and PD) have most prominent flow voids; when vascular thrombosis is identified on a T1-weighted sequence (short TE), it should be confirmed by the corresponding T2 or PD sequences, as these are less sensitive to slow flow voids and more specific to the diagnosis of thrombosis flow voids can also been seen along transverse T2-weighted images of the spine, as the CSF flows perpendicular to slice direction 2. aqueduct stenosis is a pathologic condition in which CSF flow voids are also present (Harvey et-al, 2007).

2.3.4 Tissue heterogeneity and foreign bodies

2.3.4.1 Black boundary artifact

Black boundary artifact (also known as India ink artifact, chemical shift artifact of the 2nd kind (or type 2), phase cancellation artifact, or black line artifact) is an artificially-created black line located at fat-water interfaces such as those between muscle and fat. This results in a sharp delineation of the muscle-fat boundary lending the image an appearance as if someone has outlined these interfaces with ink that is sometimes visually appealing but not an anatomical structure. (Morelli et-al, 2011).

This artifact occurs in gradient echo sequences as a result of selecting an echo time (TE) in which the fat and water spins (located in the same pixel at an interface) are out of phase, cancelling each other. At 1.5 T, the 3.5 ppm difference in frequency between water and saturated fat results in cancellation of spins at 4.5 ms multiples, starting at about 2.3 ms; for example at 6.8 ms, 11.3 ms, and 15.9 ms. This artifact does not occur with spin echo sequences as the spins are rephased by the 180o refocusing gradient. (Harvey et-al, 2007).

Case 1 is a coronal image through the upper body with an echo time of 7 ms. A black line is seen surrounding the muscles of the shoulder girdle as well as around the liver. (Gary, 2006).

Remedy

To avoid this artifact:

- choose TEs close to 4.5 ms, 9 ms, 13.6 ms.
- fat suppression can be used.
- a SE sequence instead of GE will also eliminate the artifact.

figure 2.11 show Black boundary artifact

coronal(black-border MRI artifact) (Morelli et-al, 2011).

2.3.4.2 magic angle effect

The magic angle is an MRI artifact which occurs on sequences with a short TE (less than 32ms; T1W sequences, PD sequences and gradient echo sequences). It is confined to regions of tightly bound collagen at 54.74° from the main magnetic field (B0), and appears hyperintense, thus potentially being mistaken for tendinopathy. (Morelli et-al, 2011).

Normal

In tightly-bound collagen, water molecules are restricted usually causing very short T2 times, accounting for the lack of signal. (Gary, 2006).

Artifact

When molecules lie at 54.74°, there is lengthening of T2 times with corresponding increase in signal. Thus in short TE sequences, the T2 signal does not decay significantly before the scanner picks up the signal. On the other hand, in long TE sequences (like T2WI), by the time the scanner picks up the signal, T2 signal has already decayed. The reason for this change is due to quantum mechanics: in the set of equations that describe the interaction of spins (their Hamiltonian), there are several terms that are orientation-dependent. Normally, these orientations are averaged over as protons tumble around thermally, but in sites with long-range order these terms can be important. In the case of structured collagen, lots of water binds to the outside of the protein, and therefore exhibits an orientation-dependent effect. (Harvey et-al, 2007).

Typical sites include:

- proximal part of the posterior cruciate ligament (PCL)
- infrapatellar tendon at the tibial insertion
- peroneal tendons as they hook around the lateral malleolus
- cartilage can be affected, e.g. femoral condyles
- supraspinatus tendon
- triangular fibrocartilage complex (if the patient is imaged with the arm elevated)

It appears that at 3.0T the effects are reduced. (Morelli et-al, 2011).

Other non-pathologic causes of high signal within tendons include near tendon insertions, and/or where the tendon normally fans out or merges with other tendons. (Harvey et-al, 2007).

Remedy

Tends to occur only on short TE sequences (e.g. T1, GRE, PD), sequences with a longer TE (e.g. T2 including FSE T2) can be used to avoid this artifact. (Gary, 2006).

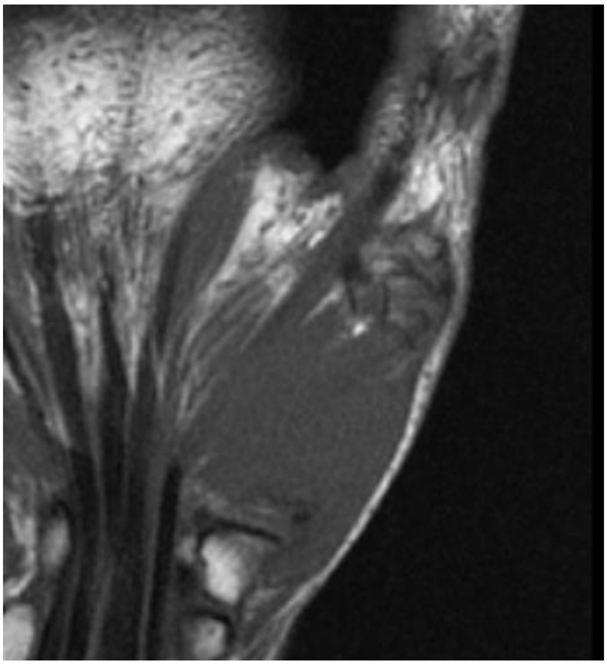

figure 2.12 show magic angle effect

T1 (magic angle effect-MRI artifact) (Morelli et-al, 2011).

2.3.4.3 magnetic susceptibility artifact

Magnetic susceptibility artifacts (or just susceptibility artifact) refer to a variety of MRI artifacts that share distortions or local signal change due to local magnetic field inhomogeneities from a variety of compounds. They are especially encountered while imaging near metallic orthopedic hardware or dental work, and result from local magnetic field inhomogeneities introduced by the metallic object into the otherwise homogeneous external magnetic field B0. These local magnetic field inhomogeneities are a property of the object being imaged, rather than of the MRI unit. A common susceptibility-related artefact, deliberately sought to make small lesions more conspicuous, is the blooming artefact. (Harvey et-al, 2007).

2.3.4.3.1Types of magnetic susceptibility

In terms of magnetic susceptibility, most materials can be classified as diamagnetic, paramagnetic, superparamagnetic, or ferromagnetic. (Harvey et-al, 2007).

2.3.4.1.1 Diamagnetic

Water is considered (weakly) diamagnetic.

2.3.4.1.2 Paramagnetic

Paramagnetic materials, which have unpaired electrons, concentrate local magnetic forces and thus increase the local magnetic field, i.e. have increased magnetic susceptibility. (McRobbie et-al, 2007).

2.3.4.1.3 Superparamagnetic

Superparamagnetic materials contain particles with a much stronger magnetic susceptibility than that of paramagnetic materials, e.g. SPIO (superparamagnetic iron oxide) has been used in liver imaging. (Westbrook et-al, 2011).

2.3.4.1.4 Ferromagnetic

Ferromagnetic materials contain large solid or crystalline aggregates of molecules with unpaired electrons exhibit “magnetic memory,” by which a lingering magnetic field is created after their exposure to an external magnetic field. Examples of ferromagnetic metals include iron, nickel, and cobalt, all of which distort magnetic fields, thereby causing severe artifacts on MR images. (Harvey et-al, 2007).

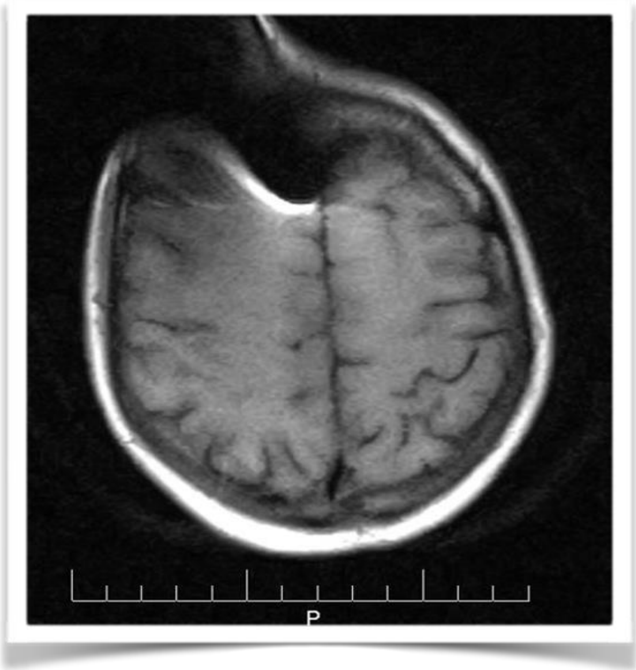

figure 2.13 show magnetic susceptibility artifact

(magnetic susceptibility artifact) (Morelli et-al, 2011).

2.3.4.4 blooming artifact

Blooming artifact is a susceptibility artifact encountered on some MRI sequences in the presence of paramagnetic substances that affect the local magnetic milieux. Although it is an artifact, it may be deliberately exploited to improve detection of certain small lesions, much as the T1 shortening effects of low concentration gadolinium are used to detect contrast enhancement. (Morelli et-al, 2011).

One of the most powerful and widely available sequences which maximises blooming to great effect is susceptibility-weighted imaging (SWI). Gradient echo and low B-value diffusion weighted imaging may also be useful in the absence of a dedicated susceptibility weighted sequence. (McRobbie et-al, 2007).

Blooming is seen surrounding a number of compounds:

- haemosiderin from prior haemorrhage, e.g.

- cavernous malformations
- old intracerebral haemorrhage
- diffuse axonal injury
- superficial siderosis
- calcification, particularly dystrophic, e.g.
- neurocysticercosis (granulomatous stage)
- metal e.g.
- surgical or traumatic fragments
- gas e.g
- air embolism

2.3.4.4.1 History and etymology

The term 'blooming' refers to the fact that lesions appear larger than they actually are. (Harvey et-al, 2007).

2.3.4.5 Chemical shift artifact

Chemical shift artifact or misregistration is a type of MRI artifact. It is a common finding on some MRI sequences, and used in MRS. (Morelli et-al, 2011).

Chemical shift is due to the differences between resonance frequencies of fat and water. It occurs in the frequency-encode direction where a shift in the detected anatomy occurs because fat resonates at a slightly lower frequency than water. Essentially it is due to the effect of the electron cloud to a greater or lesser degree shielding the nucleus from the external static magnetic field (Bo). The Larmor frequency which determines the frequency at which a particular nucleus resonates is established at the nucleus, and therefore different tissues will have slightly different Larmor frequencies depending on their chemical composition. (Gary, 2006).

A chemical shift artifact can occur in the slice select direction for an analogous reason to the frequency encoded artifact. Since the slice position depends on the frequency of the spins, the "fat image" is shifted compared to the "water image". The slice thickness is larger than the shift of the water and fat images making it difficult to detect the effect on routine imaging 2. (Gary, 2006).

The amount of chemical shift is often expressed in arbitrary units known as parts per million (ppm) of the main magnetic field strength. Its value is always independent of the main field strength and equals 3.5 ppm for fat and water; however, the precessional frequency is proportional to the main magnetic field strength Bo. For example, at 1.5 T the difference in precessional frequency is 224 Hz. That is, fat precesses 224 Hz less than water. At 1.0 T this difference is 147 Hz. At lower field strengths (0.5 T or less), it is usually insignificant in MRS the shift in Larmor frequency allows separation of different chemical peaks. The actual amount of chemical shift as an absolute value is difficult to measure, so instead it is represented relative to a reference, and expressed in parts per million (ppm). (Gary, 2006).

In MRI, both spin echo sequences (SE) and gradient echo sequences (GE) may demonstrate chemical shift misregistration or mismapping (Type 1 chemical shift artifact). The mismapping will occur in the frequency-encoding direction, and show up as a bright band on one side and a dark band on the other side of a fat-soft tissue interface. In addition to mismapping, GE sequences can show another type of chemical shift induced artifact known as the black boundary or India ink artifact (Type 2 chemical shift artifact). In the artifact a black line is seen in all directions at fat-water interfaces. In pixels with roughly equal amounts of fat and water, the fat and water spins are 180o out of phase at certain echo times because of their chemical shift or frequency difference causing cancellation of signal. (Gary, 2006).

These effects can be used to confirm, for example, the presence of intracellular fat in a lesion. chemical shift increases with magnetic field strength chemical shift increases with decreasing gradient strength chemical shift depends upon the bandwidth; the narrower the bandwidth, the higher the chemical shift. Increasing the bandwidth will decrease the artifact fat suppressed imaging can be used to eliminate the chemical shift misregistration and the black boundary artifact use of a spin echo sequence instead of a gradient echo can eliminate the black boundary artifact but not chemical shift misregistration(Harvey et-al, 2007).

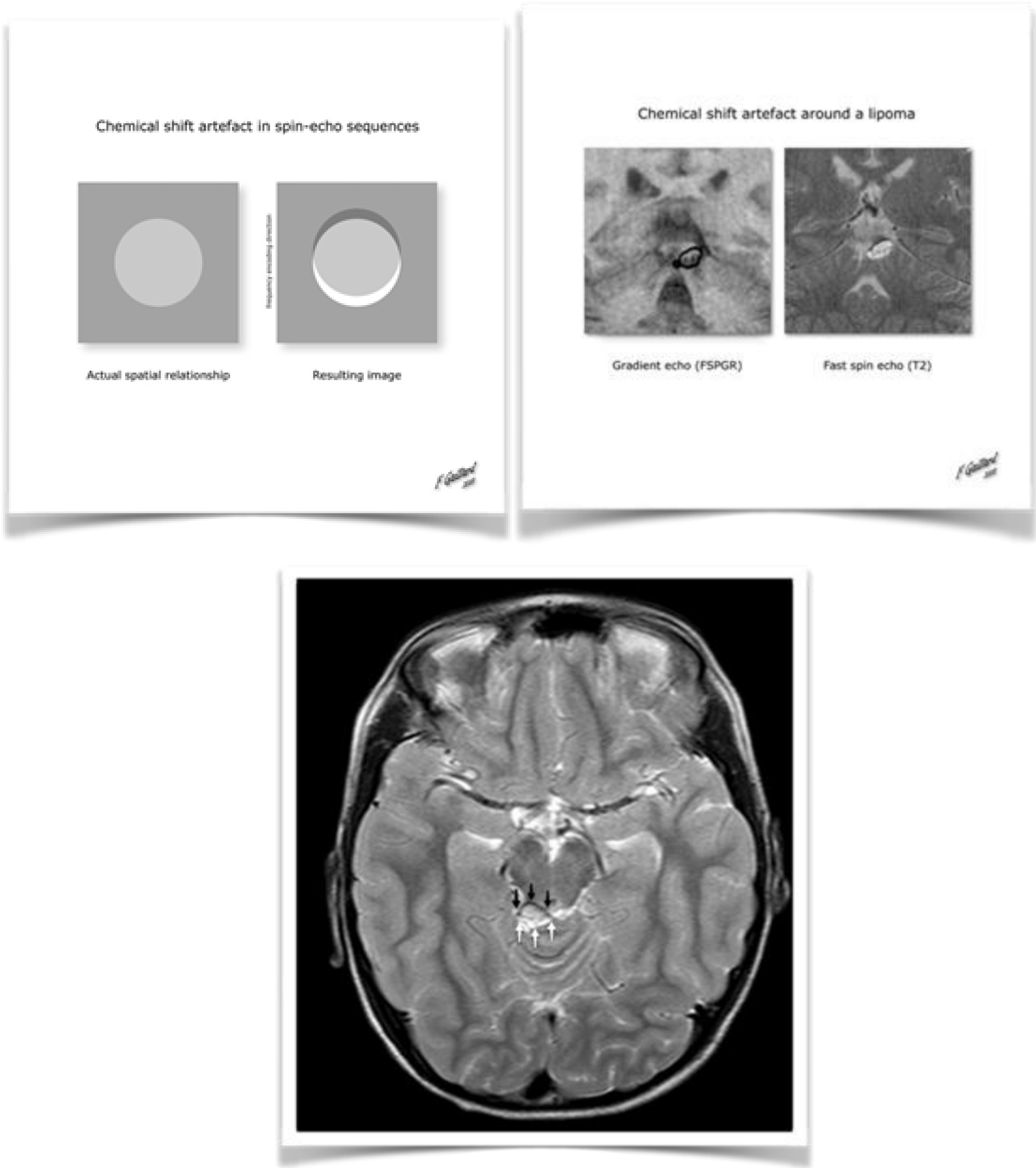

figure 2.14 show Chemical shift artifact

axial T2(quadrigeminal plate lipoma) (Gary, 2006).

2.3.4.6 dielectric effect artifact

Dielectric effect artifact is an MRI artifact encountered most often on body MRI with 3 T units.

Artifact

At 3 T, the radiofrequency (RF) wavelength measures 234 cm in air, and the speed and wavelength of the RF field is shortened to ~26 cm within the body as a result of dielectric effects. However, this 26 cm field of view is approximately the cross sectional diameter of most body imaging studies.

With patient abdominal diameters that exceed the RF wavelength (e.g. patients with cirrhosis and ascites or pregnant patients), constructive and destructive interference patterns may emerge. In body MRI this may lead to darkening/shading at the center of the image. At 7.0 T, the RF wavelength in tissue decreases to ~11 cm. (Morelli et-al, 2011).

Improvement

switch imaging to a <3.0 T system

drain ascites before imaging a patient with cirrhosis to decrease the chance of the artifact occurring(Harvey et-al, 2007).

2.3.5 Fourier transform and Nyqvist sampling theorem

2.3.5.1 Gibbs artifact/truncation artifact

Gibbs artifact is a type of MRI artifact. It refers to a series of lines in the MR image parallel to abrupt and intense changes in the object at this location, such as the CSF-spinal cord and the skull-brain interface The MR image is reconstructed from k-space which is a finite sampling of the signal subjected to inverse Fourier transform in order to obtain the final image. At high-contrast boundaries (jump discontinuity in mathematical terms), the Fourier transform corresponds to an infinite number of frequencies. Since MR sampling is finite, the discrepancy is manifest in the reconstructed image in the form of a series of lines. These can appear in both phase-encode and frequency-encode directions. (Harvey et-al, 2007).

The more encoding steps, the less intense and narrower the artifacts. Figure 1 shows the Gibbs effects resulting from Fourier transforming a sharp change in image intensity. Figure 2 shows prominent light and dark line along the sides that fade as they approach the top and bottom of the phantom. Figure 3 shows minimal artifact seen uniformly around the periphery of the phantom as a result of increasing the matrix size in the phase direction. (Gary, 2006).

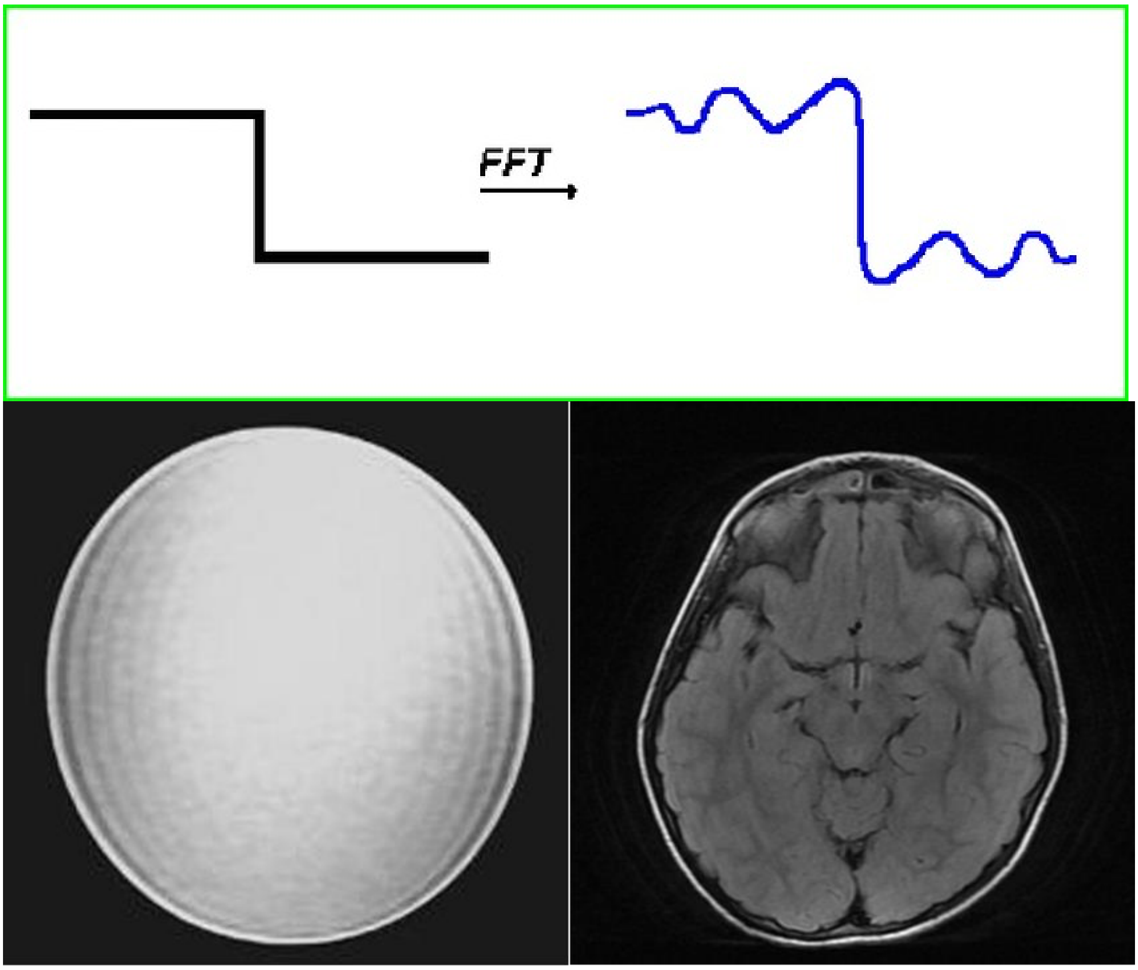

figure 2.15 show Gibbs artifact/truncation artifact

Gibbs and truncation diagram. (Gary, 2006).

.

Remedy

- increasing the matrix size (i.e. sampling frequency for the frequency direction and number of phase-encoding steps for the phase direction)
- use of smoothing filters (2-D exponential filtering, Gegenbauer reconstruction etc.)
- if fat is one of the boundaries, use fat suppression(Gary, 2006).

2.3.5.2 Zero fill artifact

Zero fill artifact is one of many MRI artifacts and is due to data in the K-space array missing or set to zero during scanning. The abrupt change from signal to no signal results in artifacts in the images showing alternating bands of shading and darkness, often in an oblique direction. A spike in k-space as from an electrostatic spark is another artifact that causes oblique stripes. (Harvey et-al, 2007).

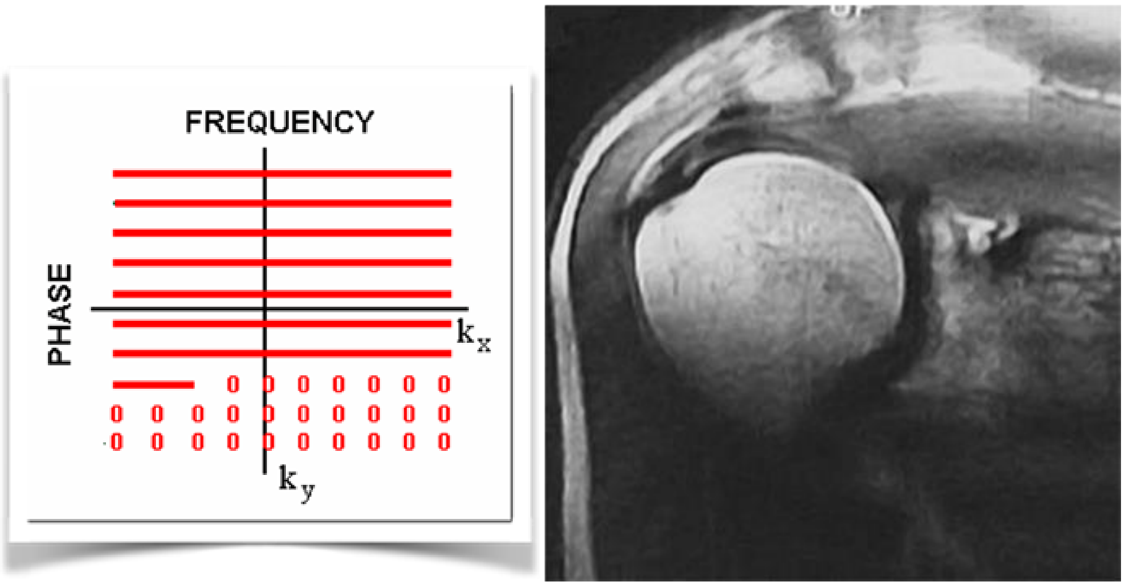

figure 2.16 show Zero fill artifact

K-space diagram(Harvey et-al, 2007).

2.3.5.3 aliasing/wrap around artifact

Aliasing in MRI, also known as wrap-around, is a frequently encountered MRI artifact that occurs when the field of view (FOV) is smaller than the body part being imaged. The part of the body that lies beyond the edge of the FOV is projected onto the other side of the image. This can be corrected, if necessary, by oversampling the data. In the frequency direction, this is accomplished by sampling the signal twice as fast. In the phase direction, the number of phase-encoding steps must be increased with a longer study as a result. However, if the FOV and matrix size (phase-encoding steps) are increased and simultaneously number of excitations (or number of signal averages) reduced to half, the imaging time can be kept constant with correction of aliasing. (Harvey et-al, 2007).

Case 1 demonstrates axial T2-weighted images of the brain that demonstrates aliasing. The first image shows wrap-around with the back of the head projected over the front because the phase-encoded direction is anterior-posterior and the FOV is too small. The second image has the phase and frequency directions reversed resulting in absence of the aliasing artifact. Oversampling was used in the frequency direction to eliminate the aliasing. (Harvey et-al, 2007).

More detail

The basis of aliasing lies in "analog-to-digital conversion" wherein the continuous MR signal picked by the receiver coil is converted into its digital counterpart for presentation as a grey-scale image. This ubiquitously involves sampling of the continuous signal at pre-defined intervals. For greater fidelity in signal conversion, the sampling rate should be at least twice the highest frequency within the signal (Nyquist rate). At lower sampling rates, high-frequency signals become indistinguishable from lower frequency signals, i.e., they become aliases. (Harvey et-al, 2007).

In MRI, spatial localisation within a single image depends on the frequency signature of the MR signal originating from that portion. Within a given bandwidth, higher frequency signals come from the periphery of the image and are aliased over the lower frequency (relatively) central portion of the image. Aliasing in MRI can occur in both phase and frequency axis. (Harvey et-al, 2007).

Remedy

Aliasing in MRI can be compensated for by:

- enlarging the field of view (FOV)
- using pre-saturation bands on areas outside the FOV
- anti-aliasing software
- switching the phase and frequency directions
- use a surface coil to reduce the signal outside of the area of interest

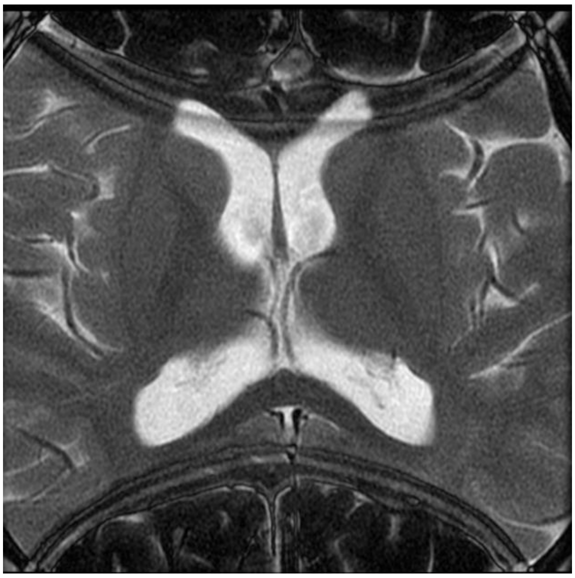

figure 2.17 show aliasing/wrap around artifact

case1: aliasing artifact (axial T2) (Harvey et-al, 2007).

Artifacts are caused by a variety of factors that may be patient-related such as voluntary and physiologic motion, metallic implants or foreign bodies. Finite sampling, k-space encoding, and Fourier transformation may cause aliasing and Gibbs artifact. Characteristics of pulse sequences may cause black boundary, Moiré, and phase-encoding artifacts. Hardware issues may cause central point and RF overflow artifacts. (Harvey et-al, 2007).

2.4 Previous studies

Study of MRI Image Artifacts in Khartoum State Centers, by al-motasem bellah yagoub ,2016

The aim of this study was to evaluate the common Artifacts in MR images in Khartoum State centers and detecting their Causes in order to give a solution for each if possible. Using observation to calculate the data along 3 month on Khartoum specialist hospitals , Artifacts in magnetic resonance images, as in different Radiologic imaging Modalities are common and lead to misdiagnosis or at least decrease the Image quality. The causes are different and as a result there are many Types of Artifacts and The result showed that the most common Artifact is Motion record High percentage 63%, the second common Artifacts was Phase mismmaping 30%, then Truncation 7%. Through my search for most common Artifacts in the magnetic resonance imaging centers in Khartoum state we found most common artifacts that is of patient movement (motion Artifacts) due to differentials reasons e.g.: unconscious patient ,lack cooperation .And Phase mismmaping Artifacts appear from involuntary motion e.g.: chest moving during respiration, also Truncation Artifacts caused by different signals high and low signals duplication transition signals, common sites appear that's artifacts in cervical spine T1 sagittal . But there are some Artifacts such as lower rates e.g.: Cross Excitation Artifacts appears in spine (Lumbar) due to not Ensuring that there is at least a 30% gap between slices. There is a previous study in Sudan; I spoke on the subject but at different rates.

Assessment of MRI Image Artifact in Khartoum State, By:El Khansa Rabie Mohammed Husain, 2015

This study to knowledge image quality and used this information will improved diagnosis image. The study was in modern medical center and Asia hospital done, during the period from (2014-2015) include numbers of patients were refer to MRI scanning, the machine used, GE (general electrical) medical system. 1.5 T and 0.2. Data collection average of case MRI artifact thwart in chart drawing by percentage, the interview radiographer was the method is used, all the radiographer are worker in center to give all information about MRI artifact, and how treatment. The research how to reduced it. In conclusion common MRI artifact done from motion artifact, we can reduced and treatment, also there are found different kind of MRI artifact few percentage, like metallic artifact and zipper artifact.

Chapter Three

Materials and Methods

Chapter Three

Materials and Method

3.1 materials

3.1.1 Study Design

cross-sectional , descriptive study.

3.1.2 Area and duration of the study

October - December , 2018

3.1 .3 MRI Machine

MRI unit	magnet type	magnet power	name of the medical center
philips	super conductive	1.5 T	DAR AL ELAJ SPECIALIZED HOSPITAL

3.1.4 Subjects

The study includes 50 patients (34 male - 16 female) underwent different MR examination and showed artifact in their images.

3.2 Methods

3.2.1 Data collection

Data were collected using a sheet for all patient in order to maintain consistency of the information from display (Appendix 1).

The data sheet was collected by the technologist observation .

3.2.2 Analysis of Data

All image artifacts recorded from monitor of the Philips MRI machine , to fill the data sheet , then used as input to the statistical software (SPSS) and Microsoft Excel for analysis.

Chapter Four

Results

Chapter Four

Results

4.1 Results:

Table 4.1 show frequency distribution for gender for all patients:

Gender	Frequency	Percent
Female	16	32.0
Male	34	68.0
Total	50	100.0

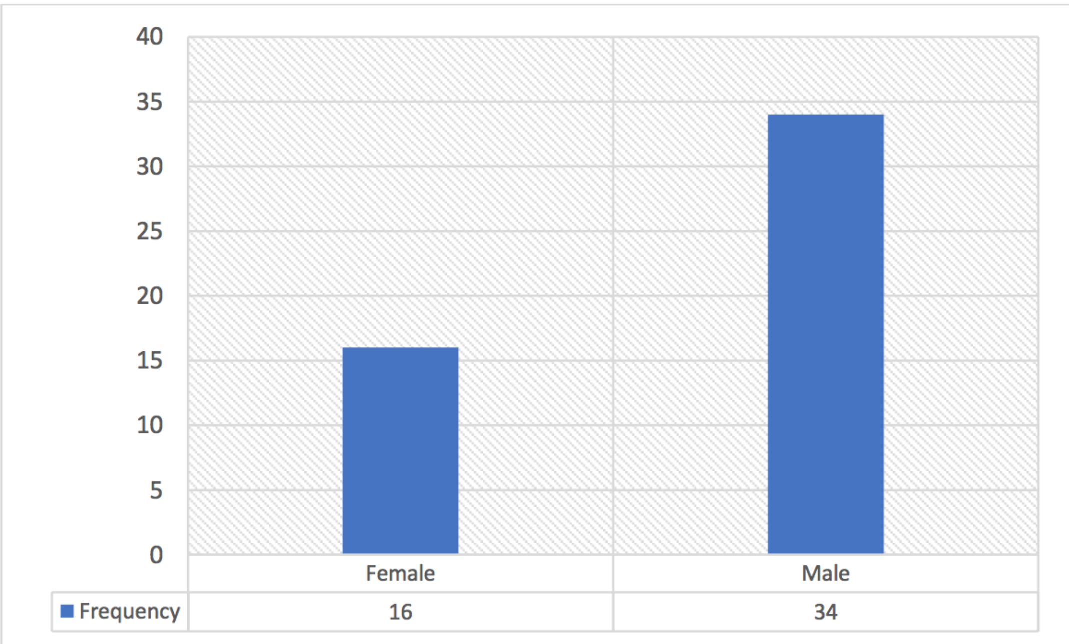

Figure 4.1 show frequency distribution for gender for all patients

Table 4.2 show frequency distribution for age group for all patients:

Age Group	Frequency	Percent
0-12	4	8.0
13-18	7	14.0
18-25	2	4.0
25-40	2	4.0
40-60	32	64.0
>60	3	6.0
Total	50	100.0

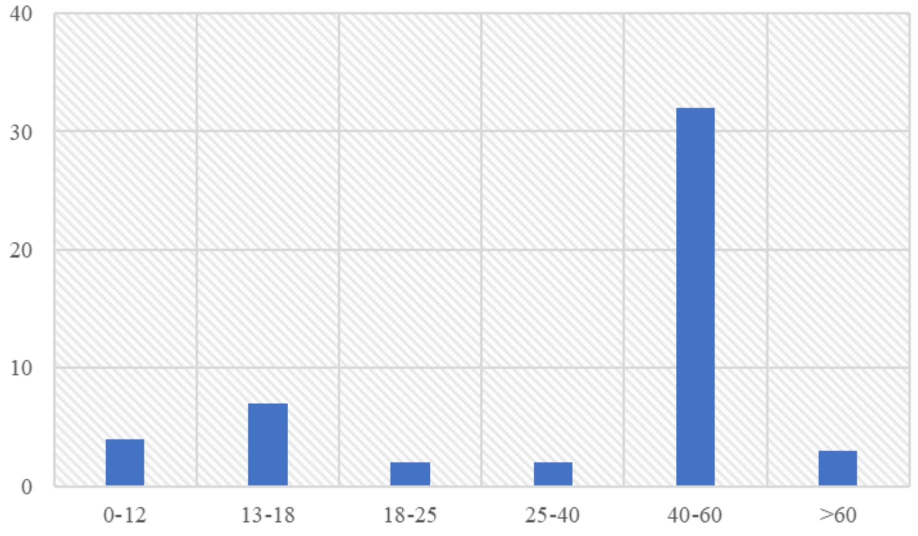

figure 4.2 show frequency distribution for age group for all patients:

Table 4.3 show frequency distribution for exams type for all patients:

Type of exam	Frequency	Percent
L/S	8	16.0
Brain	20	40.0
Knee joint	1	2.0
C/S	10	20.0
D/S	1	2.0
Shoulder joint	4	8.0
Pelvis	3	6.0
Abdomen	3	6.0
Total	50	100.0

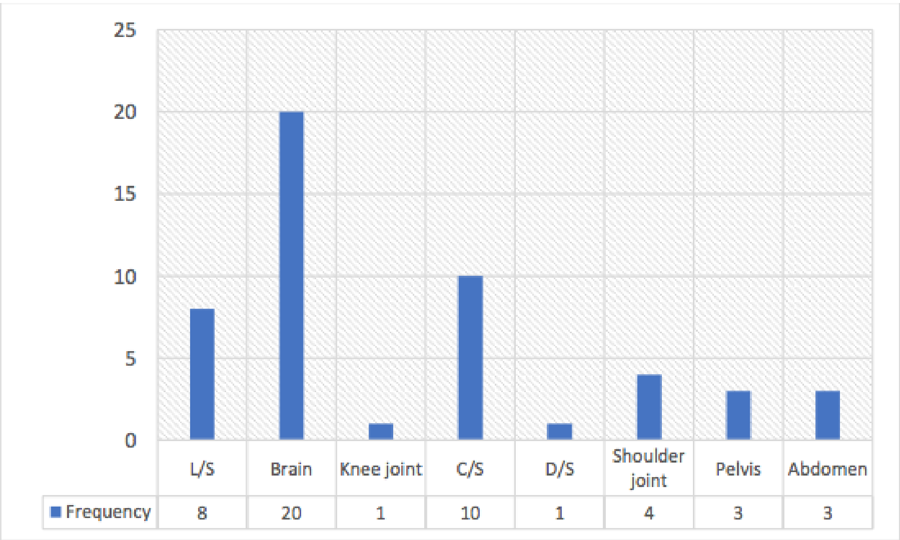

figure 4.3 show frequency distribution for exams type for all patients

Table 4.4 show frequency distribution for artifact type from MR artifact:

Type of MRI artifact	Frequency	Percent
MR software slice overlap	8	16.0
Pt motion	27	54.0
Tissue heterogeneous	8	16.0
MR hardware & room shielding	4	8.0
Fourier transform & Nyquist sampling	3	6.0
Total	50	100.0

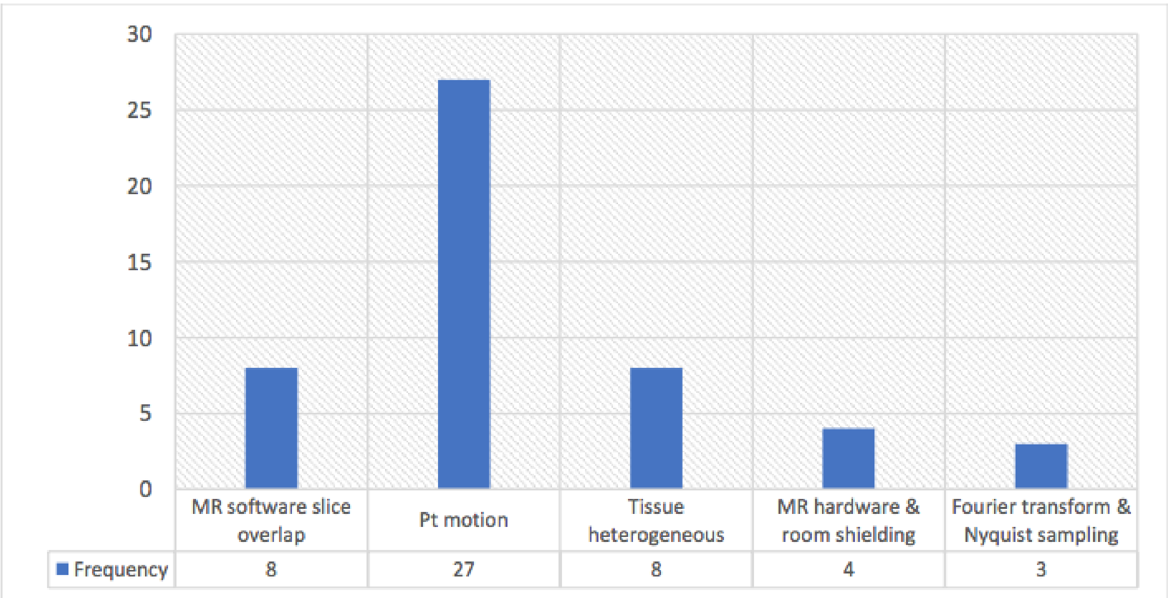

Figure 4.4 show frequency distribution for artifact type from MR artifact

Table 4.5 show frequency distribution for artifact causes from MR machines:

Cause of artifact	Frequency	Percent
Not accurate planning	15	30.0
Unconscious Pt	6	12.0
Some element of coil not working	10	20.0
Pt movement	12	24.0
No sedition	2	4.0
The field not include all the part of area of interest	3	6.0
Denture	2	4.0
Total	50	100.0

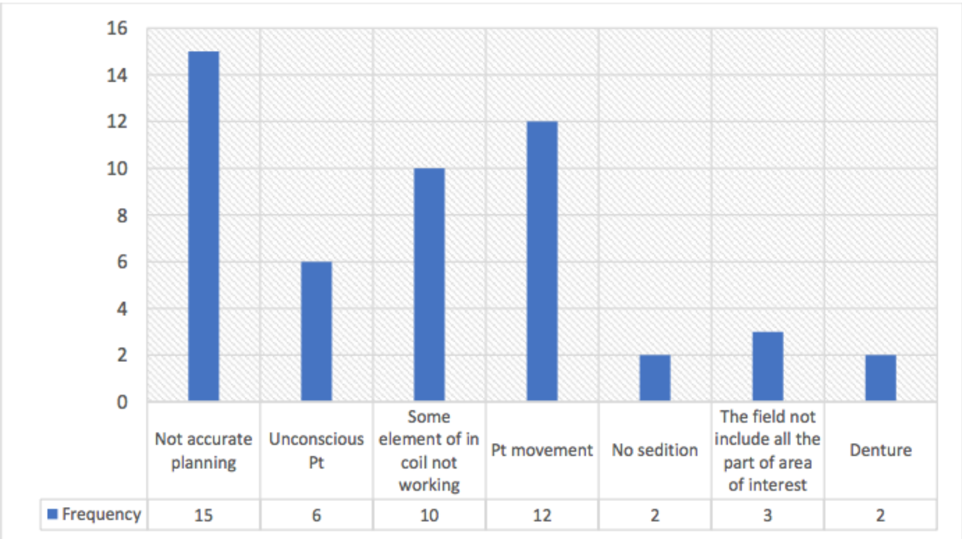

Figure 4.5 show frequency distribution for artifact causes from MR machines

Table 4.6 show frequency distribution for remedyfor MR machines:

Remedy	Frequency	Percent
More training for planning	1	2.0
Give the patient diazepam	11	22.0
Repeat the planning	25	50.0
Repeat the sequence	4	8.0
Change the pt position	8	16.0
Use Trager	1	2.0
Total	50	100.0

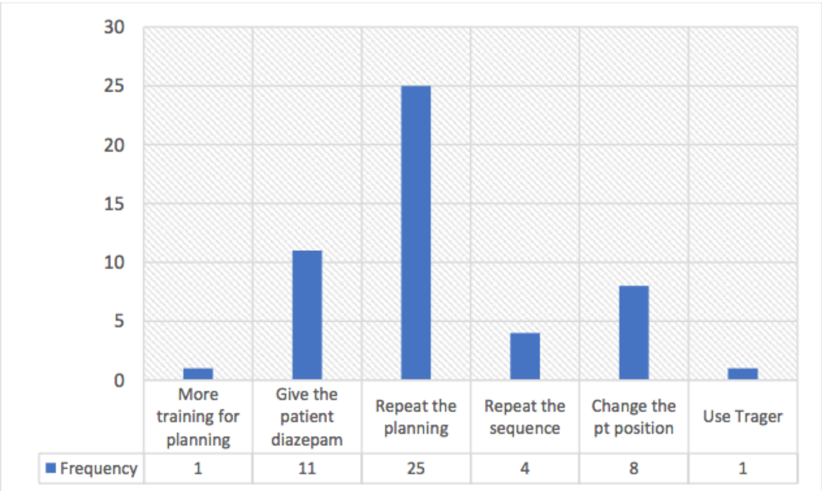

Figure 4.6 show frequency distribution for remedy for MR machines

Table 4.7 show frequency distribution for coils using for MR machines:

Coils use	Frequency	Percent
Spin Coil	20	40.0
Body Coil	26	52.0
Shoulder Coil	4	8.0
Total	50	100.0

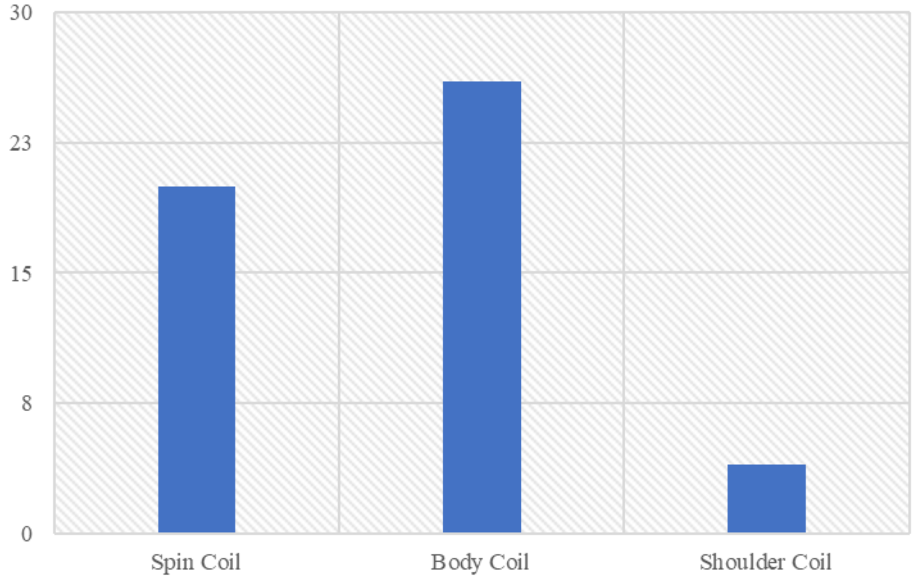

Figure 4.7 show frequency distribution for coils using for MR machines

Chapter Five

Discussion , Conclusion and Recommendation

Chapter Five

Discussion , Conclusion and Recommendation

5.1 Discussion

Artifacts in magnetic resonance images, as in different Radiologic imaging Modalities are common and lead to misdiagnosis or at least decrease the Image quality. The causes are different and as a result there are many Types of Artifacts. This aim of this study was to evaluate the common Artifacts in MR images in Khartoum State centers and detecting their Causes in order to give a solution for each if possible.

from the table 4.1 shows the frequency distribution of gender of patient which is 68 % of male and female 32% .

from the table 4.2 shows the frequency distribution of age of patient which is 4% for both age group young adults (18-25) and adulthood (25-40) , 6% for old age (60+) , 8% for infants (0-2) , 14% for adolescence (13-18) and 64% for middl of age (40-60).

from the table 4.3 the frequency distribution of examination were 2% for each knee joint and D/S , 6% for each abdomen and pelvis , 8% of shoulder joint , 16% of L/S , 20% of C/S and 40% of brain exams.

from the table 4.4 shows that the motion artifact was the most dominant type of artifact which is 54% ,then software slice overlap and tissue heterogeneous were had the same percentage (16%) for each ,the MR hardware 8% and the lowest recurrent artifact observed was fourier transform nyquist sampling by (6%).

from the table 4.5 shows the frequency distribution of MRI artifact causes which is 4% for each no sedation and denture , 6% of the field not include all the part of interest , 12% of unconscious patient , 20% of some element of coil not working , 24% of patient movement , 30% of not accurate planning .

from the 4.6 shows the frequency distribution of remedy of MRI artifacts , and it was by repeat the plaining by 50% , sedate the patient to avoid motion by 22% , change the patient position by 16% , repeat the sequence by 8% and 2% of using triger and more training for technologists .

from the table 4.7 showed frequency distribution for coils used during MR examination , the most used on the body coil withe 52% which is the highest because it’s used for multiple exams including brain because of the head coil is disabled , the spine coil occupying 40% of coils used and have some element not working need to maintenance which is the cause of some artifacts , then the shoulder coil had 8% of total.

5.2 conclusion

The result of statistical analysis showed the most common Artifacts (Motion) That is common causes of the patient motion are: Phobia, unconscious Patients, pain (especially in spine exam), a thematic patients, long Scan time, cooling condition in examination room .

The most cases which has high ratio of Artifact are Brain, Pelvis, cervical, And Shoulder, the artifacts which caused by involuntary motion controlled By software and hardware and accessories added to the MR machines, and The Artifacts caused by voluntary motion, controlled by technologists. High power of magnet play main role in improves image quality. Accessories added to machines reduced the ratio of Artifacts such as (PERU). Most of medical materials which used now a day- except electronic- to Insert in patient body, are made of non magnetic mineral, which allow the Patient to have MR image in time of necessity, without any side effect on Patient health.

5.3 Recommendation

-Good instruction and explanation should be given for the patient.
-The patients must be comfortable as possible and immobilizing them with pads and straps.

-The coils should be used according to the organs, and close the clips tightly during the preparation of the patient for examination .

the hospital must keep maintenance for MR coils spicily for head and spine coil and bring know body coil to reserve in case the used one become disable.

Continuous education should be held for Technologists .

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APPENDIX

APPENDIX

Master Data sheet

name of the medical center:																
MRI unit																
patient data	gender	group age														
	M{ } F{ }	infants (0-2){ }	children(0-12) { }	adolescence(13-18) { }	youth (13-25) { }	young adults(18-25) { }	adulthood (25-40) { }	middle age(40 -60) { }	old age(60 +) { }							
Type of exam	Brain { }	C/S { }	L/S { }	D/S { }	Orbit { }	I.A.Ms { }	Pituitary gland { }	Sinuses { }	T.M.Js { }	Hand { }	Hips { }	Knee joint { }	Ankel joint { }	Lower Limb MRA { }	Abdominal MRA{ }	
	Neck { }	Breast { }	Abdomen { }	Pelvis { }	MRCP { }	MRU { }	Shoulder joint { }	Elbow joint { }	wrist joint { }	Foot { }	Brain MRA { }	Brain MRV { }	Carotid MRA { }	Thoracic MRA { }		

type of MRI artifact	MRI hardware and room shielding { }	MRI software slice-overlap { }	patient and physiologic motion { }	tissue heterogeneity and foreign bodies { }	Fourier transform and Nyqvist sampling theorem { }
	-zipper artifact ( ) -herring bone artifact ( ) -zebra stripes ( ) -moiré fringes ( ) -central point artifact ( ) -RF overflow artifact ( ) -inhomogeneity artifact ( ) -shading artifact ( ) -aliasing artifact ( ) -wrap around artifact ( )	-cross excitation ( )	-phase encoded motion artifact ( ) -entry slice phenomena ( )	-black boundary artifact( ) -magic angle effect ( ) -magnetic susceptibility artifact ( ) -blooming artifact ( ) -chemical shift artifact ( ) -dielectric effect artifact ( )	-Gibbs artifact/truncation artifact ( ) -zero-fill artifact( ) -aliasing /wrap around artifact ( )

recurrent					
the cause of artifact					
remedy					
coils use	RF { }	GRADIENT { }	SURFACE{ }		
	VOLUME { }	SHIM { }	ARRY{ }		
	EXTREMITY{ }				
pulse sequences	spin echo{ }	inversion recovery { }	gradient echo{ }		
	diffusion weighted { }	saturation recovery{ }	echo-planer pulse{ }		
	spiral pulse{ }				
image weight	T1{ }	T2{ }	P{ }		
	T*{ }	STA{ }	FLAIR{ }		
explain the procedure	always{ }	sometimes{ }	rare{ }	never{ }	
technologies qualification	experience :				