Introduction

Purcell discovered the magnetic resonance phenomenon
independently.

The properties of magnetic resonance were first discovered in the 1940s by separate research groups headed by Bloch and Purcell. Their work led to the use of MRI spectroscopy for the analysis of complex molecular structures and dynamic chemical processes. In 1952 Bloch and Purcell were jointly awarded the Nobel Prize in physics, and spectroscopic MR is still in use today.

Nearly 20 years after the properties of MR were discovered
Damadian showed that the relaxation time of water in a tumor differed
from the relaxation time of water in normal tissue. This finding suggested that image of the body might be obtained by producing maps of relaxation rate. In 1973 Lauterbur published the first cross-sectional images of objects obtained with MRI techniques. These first images were crude, and only large objects could be distinguished. Since that time.. MRI technology has developed so much that tiny structures can

be imaged rapidly with increased resolution and contrast.

1970s for the first brain MRI the subject had to sit still for eight hours and images took 72 hours to develop.

In 1975 Richard Ernst proposed MRI using phase frequency
encoding, and the flourier transformation. This technique is the basis of
the current MRI.

1977 Raymond Damadian Demonstrated MRI of the whole body.
In 1980 a singled image could be acquired in approximately five minutes by Ernst techniques.

By 1986 the imaging time was reduced to about five seconds
without sacrificing too much image quality.

In 1987 echo – planer imaging was used to perform real time movie imaging of a single cardiac cycle. So in the same year Charles Dumoulin was perfecting magnetic Resonance angiograph (MRA) which allowed imaging of flowing blood without the used of contrast agent.

In 1993 functional MRI was developed, this technique allows the mapping of the function of the various regions of the human brain (EPI.). Till 1994 MRI was still a young but growing science.
In 1999 Magnevu developed the first truly portable MRI technology and made it available for clinical use.

In Sudan MRI entered in 1998 in Suba teaching hospital, Co-operative with foreign company, with old fashion and old machine
and exported.

Till July 2001 we did have G.E. 0.2 Tesla MRI unit at military
base hospital, followed by Philips 0.5 Tesla unit at Yastabshroon medical center. Then the third was Khartoum MRI center (Doaa) magnum 1.0 Tesla,

Then Elbaraha center semins 1.5 Tesla, police hospital semins 1.5 Tesla and Khartoum advanced Diagnostic center Philips 1.5 Tesla.

The progress of magnetic resonance imaging (MRI) as a clinical tool has been extraordinary, outstripping the rate of development of any other image technique. Advance in MRI computer software and electronics led to improved imaging applications, particularly with the introduction of vascular imaging known as magnetic resonance angiography or MRA.(cathrin west book,1999)

In magnetic Resonance Imaging, which is based on the physical principle of magnetic resonance (MR), diagnostic cabability is expanded by combining several parameters to obtain image contrast.

Among these, the proton density and the relaxation time are two of the most important parameters for the magnetization of the tissue under examination.(john a, et al ,1998)

MRI is now essential to the clinical management of neurological and musculoskeletal disease and application in other areas are constantly being defined .

In come cases contrast media is used, when required it is for different lesions.

Several processes must be completed in order to produce

magnetic resonance images. These processes include alignment,

Radiofrequency expiation, spatial encoding and image information.

The hard ware required to complete such processes includes:

A magnet, Radio frequency source, and image processor and

computer system. (pul m et al,2001)

Magnetic resonance is an imaging modality that introduces

energy into the patient via RF coils.

The same energy is returned and collected by a receive coil to create an image. The energy received has been modulated and altered by tissues, vessels, and magnetic fields. By the time the energy returns to the imaging coil it has changed drastically, carrying with it information that ill be used to represent the patient's anatomy. But not only does the return signal carry a two-dimensional impression of the three-dimensional area that was energized, it can also carry false information. (Catherin west book, 1999)

When it appears on the image often it can obliterate the signal from the tissue being imaged and mimic pathology. This false information is called an artifact. All MRI images have artifacts to some degree. It is there form very important that the causes of these artifacts are understood and compensated for if possible.

Some artifacts are irreversible, and may only be reduced rather than eliminated. Others can be avoided altogether.(Catherin west book et al , 1998)

Artifact can arise from machine, technique used and patient. In this research I discussed different types of artifacts that a part of MR imaging with their causes and compensation.

1.2 Objectives of the study:

a) Important of considerate image quality.
b) To determine the MR images artifacts in Machine.
c) To determine the causes of the MR images artifacts in MR1 .5T

d) To State how to avoid the MR images artifacts.

1.3 Problems of the study:

There are many MRI artifacts their causes are unknown, in this study there is a trial determine some of them.

1.4 Importance of the study:

To gain a high images quality without any artifacts.

The overview:

To make the aims of the project stated above true, thesis falls into five chapter : Chapter one which is an introduction , deals with theoretical frame work of the study. it present the statement of the study problems and objective of the study . and thesis outcome chapter tow: deals with theoretical background of image quality. while chapter three discuses the material and method and chapter four include presentation of the result and finally chapter five dials with the discussion , recommendation , conclusion of the study performed as well as future work.

Chapter two

2. Literature Review and Theoretical

2.1 The MR component

2.1.1 The magnet:

The homogeneous magnetic field required for MR imaging is
generated by a strong magnet. This magnets if the most important and expensive component of the MR system.

The strength of the magnetic field, expressed by the notation(B), or in the case of more than one field, primary field (Bo) and the
secondary field (B1), can be measure in one of three units: gauss
(G), Kilogauss (Kg), and Tesla (T). Tesla is the unit used to measure higher magnetic field strength. One Tesla equal 10 (kg) equal 10.000 G.

Most MR systems operate form as low as 0.3 T to as high as 2 T
range. There are many hazards created by the presence of the magnetic field. Ferrous objects are attracted by the magnetic field and can act as projectiles, being pulled by the magnetic field if

brought the too close to the magnet. Serious injury or damage could result. Also, common Hospital equipment may be adversely affected when in proximity to the magnetic field, or image quality may be affected by the presence
of this equipment.(Catherin west book et al, 1998)

There are three basic types of magnets used in MR systems:-

2.1.1.1 Resistive magnets:

The magnetic field strength in a resistive magnet is dependent
upon the current which passes through its coils of wire the direction of main magnetic field in resistive magnet follow the right hand thumb rule, and produces lines of flux running horizontally from the head to the foot of the magnet. As resistive system primarily consists of loops carrying current, it is lighter in weight than the permanent magnet and although its capital quite high due to the large quantities of power required to maintain the magnet field. The maximum field strength in a system of this type is less than 0.3T due to its excessive power requirements.(Catherin west book et al ,1998)

2.1.1.2 Permanent magnet:

Its magnet field is always there and always on full strength, so
it costs nothing to maintain the field. The major draw back is thatthese magnets are extremely heavy – many, tons in weight at the 0.4
Tesla level. A stronger field would require a magnet so heavy it
would be difficult to construct. Permanent magnets are getting
smaller, but are still limited to low field strength.

2.1.1.3 Superconducting magnets:

Are the most commonly used a resistance decrease the current
dissipation also decreases. A superconducting magnet is some what similar to resistive magnet coils or windings of wire through which a current electricity is passed create the magnet field.

The important difference is that the wire is continually bathed
in liquid helium at 452.4 degrees below zero cold causes the
resistance in the wire to be drop to zero, reducing cold causes the resistance in the wire to be drop to zero; reducing the electrical requirement for the

system and making it much more economical to operate. Superconductive systems are very expensive, but they can easily generate 0.5 Tesla to 2T field allowing for much high quality imaging. (Catherin west book et al, 1998)

2.1.2 The coils:

2.1.2.1 Shim coil

Due to design limitations it is almost impossible to create an
electro- magnet which produces a perfectly homogenous magnetic field.

To correct for these inhomogeneities, other loops of current
carrying wire are placed around the bore.

This process is called shimming and the extra loop of wire is called a shim coil. Shim coils produce magnetic field evenness of homogeneity. For imaging purpose, homogeneity of the order of 1.0 pmm is required. Spectroscopic procedures require a more
homogeneous environment of 1 pmm.

The shim system requires a power supply which is separate from the other power supplies within the system. This is important because a fault in the shim power supply compromises image quality. (Catherin west book et al , 1998)

2.1.2.2 Gradient Coils:

The gradient coils are the three sets coils within the magnet
housing. Running through these coils in a specified manner creates controlled and graded variations in the static magnetic field, thus affect nuclear precessional frequency in away given voxel of anatomy and allowing for spatial detection of signal within slice.

An MRI system uses three gradient coils, each affects a
different plane, the XY, YZ or XZ plane, as it is turned on and off at different points in a pulse sequence. How all three are used depends on the scan plane and the pulse sequences being used, the system calculated this automatically.(Catherin wets book et al ,1998)

2.1.2.3 RF coils :

MRI machines come with many different coils designed for
different parts of the body: knees, shoulders, wrists, head necks and so on. These coils usually conform to the contour of the body part being

imaged, of at least reside very close to it during the exam. At approximately the same time, the three gradient magnets jump into the act. They are arranged in such a manner inside the main magnet that when they are turned on and off very rapidly in a specific manner, they alter the main magnetic field on a very low level. What this means is
that we can pick exactly what area we want a picture of in MRI we speak of " slices ". We can " slice " any part of the body in any director giving us huge advantage over any other imaging modality. This means the machine will not move to get an image from a different direction, the machine can manipulate everything with the gradient magnets.
RF coils are the " antenna " of the MRI system that broadcasts the RF signal to the patient and / or receives the return signal. RF coils can be receive-only, in which case the body coil is used as a transmitter, or transmit and receive (transereceiver).
Surface coils are the simplest design of coil. They are simply a
loop of wire, either circular or rectangular, that is placed over the region of interest. The depth of the

image of a surface coils is generally limited to about one radius. Surface coils are commonly used for spines, shoulders TMJ's, and other relatively small body parts.

Paired saddle coils are commonly used for imaging of the knee. These coils provide better homogeneity of the RF in the area

of interest and are used as volume coils, unlike surface coils. Paired saddle coils are also used for the x and y gradient coils. By running current in opposite directions in the two halves of the gradient coil. The Helmholtz pair coils consist of two circular coils parallel to each other. They are used as z gradient coils in MRI scanners. They are also used occasionally as RF coils for pelvis imaging and cervical spine imaging.

The bird cage coil provides the best RF homogeneity of all the

RF coils. It has the appearance of a bird cage; hence, its name. This coil is commonly used as a transceiver coil for imaging of the head.

This type of coil is also used occasionally for imaging of the

extremities, such as the knees.(Catherin west book et al .1998)

2.1.3 The Computer system :

We have the computer that directs all of the action in the MRI
acquisition and acquires and processes the data. The computer tells the gradient amplifiers and RF transmitter when to turn on and off to obtain the proper pulse sequence. The RF receiver amplifier is also controlled by the computer and relays the signal received by the RF coil from the patient to the A-D converter that digitizes the signal, and from there to the computer to be reconstructed into an image.(Catherin west book et al , 1998)

2-2 Physics MRI

It is the function of proton spin density and relaxation time.

The MRI consists generally of three parts.

Input … output devices and central processing unit.(Catherin west book ea al ,1998)

2-2-1 The input devices

- Primary magnet**.**
- RF trans-receiver coil.
- Gradient coil.
- In addition to the ordinary computer input devices including the processing unit that use to reconstruct the MRI image and display it on the screen or store it in a disk. (Catherin west book et al ,1998)

2-2-2 Physical principal

- MRI image depend on the presence of protons.
- The proton is electrically charged and it rotates around its axis (spinning).
- This rotation generate a magnetic field around each proton.

- In our body these tiny bar magnets (protons) are ordered in such a way that the magnetic forces equalize.
- Water consists of 2 Hydrogen and 1 Oxygen atom.
- The hydrogen atom has 1 proton and 1 electron.
- The proton in the hydrogen were used to generate MRI image. Why?
- First off all we have a lot of them in our body.
- Second the gyro magnetic ratio for Hydrogen is the largest; 42.57 MHz/Tesla.
- When we put a person in a magnet some interesting things happen to the hydrogen protons:
- They align with the magnetic field. This is happened in two ways, parallel and anti-parallel.
- They precess or “wobble” due to the magnetic momentum of the atom.
- They precess at the Larmor frequency.
- Larmor frequency can be calculated from the following equation:

$$\omega_0 = \gamma \, B_0$$

Where: ω_0 = Precessional or Larmor frequency. (MHz)

γ = Gyro Magnetic Ratio. (MHz/T)

B_0 = Magnetic field strength. (T)

- We need the Larmor frequency to calculate the operating frequency of the MRI system.
- If we have a MRI system of 1.5 Tesla then the Larmor or precessional frequency is: 42.57 x 1.5 = 63.855 MHz.
- The parallel are in the low energy state and the anti parallel are in the high energy state.
- protons are, just like many people, lazy. They prefer to be in low energy state.
- There are more protons aligned parallel or low energy state than there are anti-parallel or high energy state.

it’s not that big a difference. The excess amount of protons aligned parallel within a 0.5T field is only 3 per million

in a 1.0T system there are 6 per million

in a 1.5T system there are 9 per million.

So, the number of excess protons is proportional with B0.

a voxel is 2 x 2 x 5 mm = 0.02 ml

Avogadro's Number says that there are 6.02 x 10^{23} molecules per mole.

1 mole of water weighs 18 grams (O^{16} + $2H^{1}$), has 2 moles of Hydrogen and fills 18 ml, so…………

1 voxel of water has 2 x 6.02 x 10^{23} x 0.02 / 18 = 1.338 x 10^{21} total protons

The total number of excess protons =

(1.338 x 10^{21} x 9)/2 x 10^{6} = 6.02 x 10^{15} or 6 million billion!!!

At the end we see that there is a net magnetization (the sum of all tiny magnetic fields of each proton) pointing in the same direction as the system's magnetic field. with this net magnetization we continue.

The Z-axis is always pointing in the direction of the main magnetic field, while X and Y are pointing at right angles from Z. Here we see the (red) net magnetization vector pointing in the same direction as the Z-axis. The net magnetization is now called Mz or longitudinal magnetization.

To obtain an image from a patient it is not enough to put him/her into the magnet. We have to do a little bit more than that.

This can be summarized into 5 major steps:

Excitation, Relaxation, Acquisition, computing and display(Catherin et al , 1998)

2-2-3 Excitation

Before the system starts to acquire the data it will perform a quick measurement (also called pre-scan) to determine at which frequency the protons are spinning (the Larmor frequency). This centre frequency is important because this is the frequency the system uses for the excitation step.

In the excitation step the proton were excited by sending and RF frequency.

Let us assume we work with a 1.5 Tesla system. The centre or operating frequency of the system is 63.855 MHz.

In order to manipulate the net magnetization we will therefore have to send an Radio Frequency (RF) pulse with a frequency that matches the centre frequency of the system 63.855 MHz.

This is where the Resonance comes from in the name Magnetic Resonance Imaging.

protons that spin with the same frequency as the RF pulse will respond to that RF pulse.

Therefore the net magnetization will be "flipped" 90º.

It is possible to flip the net magnetization any degree in the range from 1º to 180º.

This process is called excitation.(Catherin west book et al , 1998)

2-2-4 Relaxation

We rotated the net magnetization 90º into the X-Y plane.

This happened because the protons absorbed energy from the RF pulse.

This is a situation that the protons do not like.

You could compare this with walking on your hands, it is possible but you don't like it for a long time.

You prefer to walk on your feet. Same thing for the protons, they prefer to align with the main magnetic field

Now something happens that is referred to as Relaxation.

The relaxation process can be divided

into two parts: T1 and T2 relaxation.(Catherin west book et al , 1998)

2-2-4-1 T1 Relaxation

The protons want to go back to their original situation.

They do so by releasing the absorbed energy in the shape of (very little) warmth and RF waves.

In principle the reverse of excitation takes place.

The net magnetization rotates back to align itself with the Z-axis.

T1 relaxation is also known as Spin- Lattice relaxation, because the energy is released to the surrounding tissue (lattice).

T1 Relaxation Curves

T1 relaxation happens to the protons in the volume that experienced the 90º-excitation pulse.

not all the protons are bound in their molecules in the same way.

One ^{1}H atom may be bound very tight, such as in fat tissue, while the other has a much looser bond, such as in water.

T1 Relaxation Curves

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One ^1H atom may be bound very tight, such as in fat tissue, while the other has a much looser bond, such as in water.

Tightly bound protons will release their energy much quicker to their surroundings than protons, which are bound loosely.

The rate at which they release their energy is therefore different. The rate of T1 relaxation can be depicted

T1 is defined as the time it takes for the longitudinal magnetization (Mz) to reach 63 % of the original magnetization.

Each tissue will release energy (relax) at a different rate and that's why MRI has such good contrast resolution.

2-2-4-2 T2 Relaxation

T1 and T2 relaxation are two independent processes.

The only thing they have in common is that both processes happen simultaneously.

T1 relaxation describes what happens in the Z direction, while

T2 relaxation describes what happens in the X-Y plane.

Phase and Phase coherence

Ever heard of Phase?

if you see a group of soldiers marching along the road they all put their left leg forward at the same time. The sergeant tells them to do so: Left, Right; Left, Right, Left . . . Left . . . Left, Right. You could say that the group is walking in phase or in synchronization.

Incase of proton:

The net magnetization vector (as mentioned before) is the sum of all the small magnetic fields of the protons, which are aligned along the Z-axis.

Each individual proton is spinning around its own axis.

Although they may be rotating with the same speed, they are not spinning *in-phase* or, in other words, there is no phase coherence.

When we apply the 90º RF pulse apart from flipping the magnetization into the X-Y plane, the protons will also start spinning *in-phase*!!

But because the magnetic fields of each vector are influenced by one another the situation what will occur that; one vector is slowed down while the other vector might speed up.

they will start to de-phase.

At first the amount of de-phasing will be small.

but quickly that will increase until there is no more phase coherence left.

This process of getting from a total *in-phase* situation to a total *out-of-phase* situation is called T2 relaxation.

T2 Relaxation Curves

Just like T1 relaxation, T2 relaxation does not happen at once. Again, it depends on how the Hydrogen proton is bound in its molecule and that again is different for each tissue.

Right after the 90º RF-pulse all the magnetization is “flipped” into the XY plane. The net magnetization changes name and is now called M_{XY}. At time = 0 all spins are in-phase, but immediately start to de-phase. T2 relaxation is also a time constant.

T2 is defined as the time it takes for the spins to de-phase to 37% of the original value.(Catherin west book et al ,1998)

2-2-5 Acquisition

During the relaxation processes the spins shed their excess energy, which they acquired from the 90º RF pulse, in the shape of radio frequency waves. In order to produce an image we need to pick up these waves before they disappear into the space.

This can be done with a Receive coil

If we assume we have a 100% homogeneous magnetic field then all the protons in the body would spin at the Larmor frequency.

This also means that all protons would return signal.

How do we know whether the signal is coming from the head or from the foot?

The solution to this problem can be found in the properties of an RF-wave, which are: phase, frequency and amplitude.

First we will divide the body up into volume elements, also known as: voxels.

Then we are going to code the voxels such that the protons, within that voxel, will emit an RF wave with a known phase and frequency.

The amplitude of the signal depends on the amount of protons in the voxel.

This could be done using the Gradient Coils. (Catherin west book et al , 1998)

2-2-6 Gradient coil

Gradient coils are a set of wires in the magnet, which enable us to create additional magnetic fields, which are, in a way, superimposed on the main magnetic field B0.(Catherin west book et al , 1998)

2-2-7 Signal Coding

Slice Encoding Gradient

If the Z- gradient is switched on. This will generate an additional magnetic field in the Z direction, which is superimposed on B0.

The indication +Gz means there is a slightly stronger B0 field in the head as there is in the iso-centre of the magnet.

A stronger B0 field means a higher Larmor frequency.

Along the entire slope of the gradient there is a different B0 field and consequently the protons spin at slightly different frequencies.

if we apply an RF-pulse with a frequency of 63.7 MHz ONLY the protons in a thin slice in the head will react because they are the only ones which spin with the same frequency.

Within the slice there are still a lot of protons and we still don’t know from where the signal is coming from within the slice.

Whether it comes from anterior, posterior, left or right, further encoding is therefore required in order to allow us to pinpoint the exact origin of the signals.(Catherin west book et al ,1998)

2-2-8 Phase Encoding Gradient

In order to code the protons further the Gy gradient is switched on very briefly.

During the time the gradient is switched on an additional gradient magnetic field is created in the anterior-posterior direction.

The effect is that the anterior protons will spin slightly faster than the posterior protons.

When the Gy gradient is switched off, each proton within the slice spins with the same frequency BUT each has a different phase.

We can determine two things:

1. The signal comes from a slice in the head. (Slice Encoding)

2. The signal contains a number of RF waves, which have the same frequency, but have different phases.

It is possible to tell whether the signal comes from anterior or from posterior. (Phase Encoding)

All we need to do now is to do one more encoding to determine whether the signal comes from the left, the centre or the right side of the head.

Frequency Encoding Gradient

To encode in the left – right direction the third, and last, gradient (Gx) is switched on.

This will create an additional gradient magnetic field in the left – right direction.

The protons on the left hand side spin with a lower frequency than the ones on the right.

They will accumulate an additional phase shift because of the different frequency, but – and this is utterly important - the already acquired phase difference, generated by the Phase Encoding gradient in the previous step, will remain.

Therefore We can pinpoint the exact origin of the signals, which are received by the coil using the frequency and the phase.(Catherin west book et al , 1998)

2-3 MR image quality:

The main consideration image quality are:

2-3-1Signal to noise ratio (SNR)

SNR may be increased by using:

- Spin echo (SE) and fast spin echo (FSE) pulse sequences.
- A long repetition time (TR) and a short echo time (TE).
- A flip angle of 90
- A well-tuned and correctly sized coil.
- A coarse matrix. (Catherin west book et al , 1998)

2.3.2 **Contrast to noise ratio:**

The CNR between pathology and other structures can be increase by:

- Administration of contrast agents.
- Utilization of T2 weighted sequences.
- Selection of magnetization transfer (Mt) sequences(Catherin west book et al, 1998).

2.3.3 **Special resolution.**

The special resolution Increase by:

- Thin slices.
- Fine matrices.

- A small FOV.(Catherin west book et al, 1998)

2.3.4 **Scan time:**

Scan time be decreased by using;

- A short TR.
- A coarse matrix.
- The lowest NEX/NSA possible. (Catherin west book et al,1998)

2-4 MRI artifacts :

Items of magnetic resonance (MR) image, artifact is an abnormal area of signal in the image that does not normally arise from patient anatomy or pathology.

An artifact may be defined as an object that has been intentionally made or produced for a certain purpose. Also an

artifact' is sometimes used to refer to experimental results which are not manifestations of the natural phenomena under investigation, but are due to the particular experimental arrangement.(Catherin wet book et al , 1998)

MRI Artifacts: causes and their compensation :

2. 4.1Ferromagnetic Artifacts :

(Magnetic susceptibility artifact)

Magnetic susceptibility is the ability of a substance to be

magnetized. Is caused by focal distortions in the main magnetic field due to presence of ferromagnetic objects such as orthopedic devices, surgical clips and wire, dentures, and metallic foreign bodies in the patient. The artifact is seen as signal void at the location of the metal implant, often with arim of increased intensity and distortion of the image in the vicinity.(Catherin west book et al , 1998)

2.4.1.1.1 The remedy of M.S

Removed all metal items where possible before scan.

The use of spin echo sequences reduces the artifact.

MS can be used to aid diagnosis in case of hemorrhage

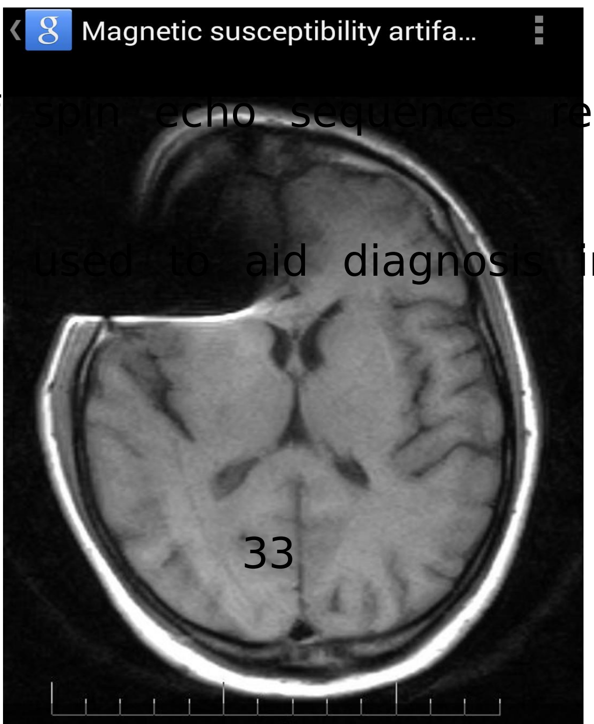

Figure: (2-4-1-1) axial T1 weight image of brain showed Susceptibility Artifacts.(www.radiopaedia.org)

Figure: (2-4-1-1)coronal T2weigth image of brain showed Susceptibility Artifacts (www.radiopaedia.org)

2.4.1.2 Phase Mismaping (Motion+Ghosting)

Is produced and originates form any structure that moves during acquisition of data, for example, chest wall during respiration, pulsatile movement of vessels, swallowing , eye movement…ect.

· This artifact may result in fuzziness on the image or a lack of details.

· Phase mismaping always occurs during along the phase encoding axis. This due to the inherent time delay between phase encoding and readout.(Catherin west book et al, 1998)

2.4.1.2.1 **The remedy of ghosting artifact**

- Changing direction of phase encoding axis, so that the artifact does not interfere with area of interest.
- A process known as pre-saturation null signal from specified
- areas. Placing pre-saturation volumes over the area producing artifact nullified signal and reduces the artifact.

- Used respiration compensation.
- Gating (ECG, Peripheral.)(Catherin west book et al ,1998)

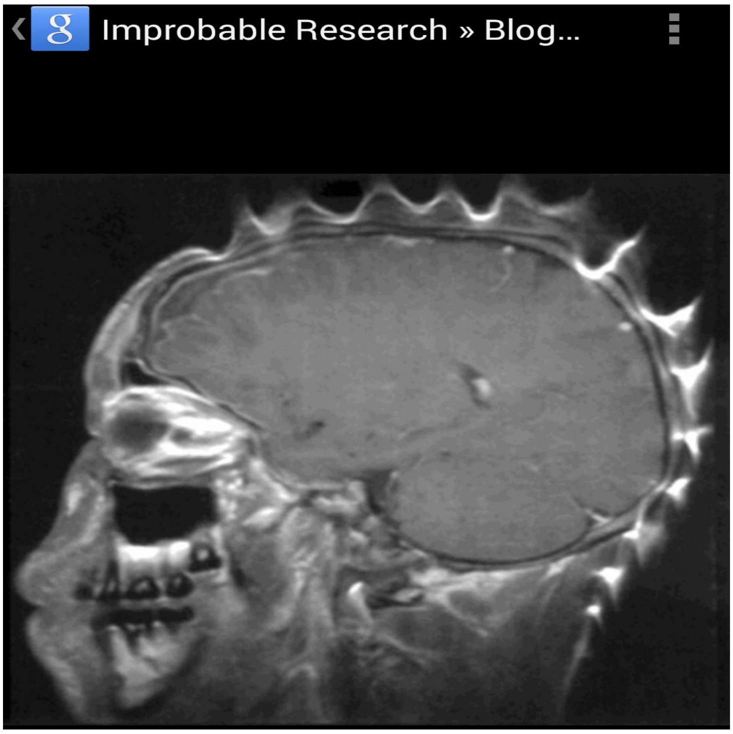

Figure: (2-4-1-2) sagital T2 of brain showed (Motion Ghosting)artifact(www.radiopaedia.org)

2.4.1.3 Chemical shift artifact

Occurs at bound interfaces between fat and water. Protons in lipid molecules experience a slightly lower magnetic influence than protons in water when exposed to an externally applied gradient magnetic field resulting in misregistration of signal location.

This occurs along the frequency encoding axis. (Catherin west book et al , 1998)

2.4.1.3.1 The remedy of chemical shift

· Scanning at low field.

· Keeping (FOV) to minimum.

· At high field strengths the size of receive band width is the

one way of limiting chemical shift. Widest band width.(

Figure: (2-4-1-3)sagital proton density of Brian red arrow showed (Chemical shift artifact)(www.radiopaedia.org)

2.4.1.4 Chemical misregristraion

· This artifact is caused by the difference in processional
frequency between fat and water.
Which are in phase at certain times and out of phase at others.
· Fat and water in phase their signal is added.
· Fat and water out of phase their signal cancel each other out.
· This cancellation causes a ring of a dark signal around

certain organs where fat and water interface occur within the
same voxel. (Catherin west book et al ,1998)

2.4.1.4.1 The remedy of chemical misregistration

· Use (SE) or fast spin echo (FSE) pulse sequences.

· Use a TE that matches the periodicity of fat and water
so that the echo is generated when fat and water are in phase.(Catherin west book et al ,1998)

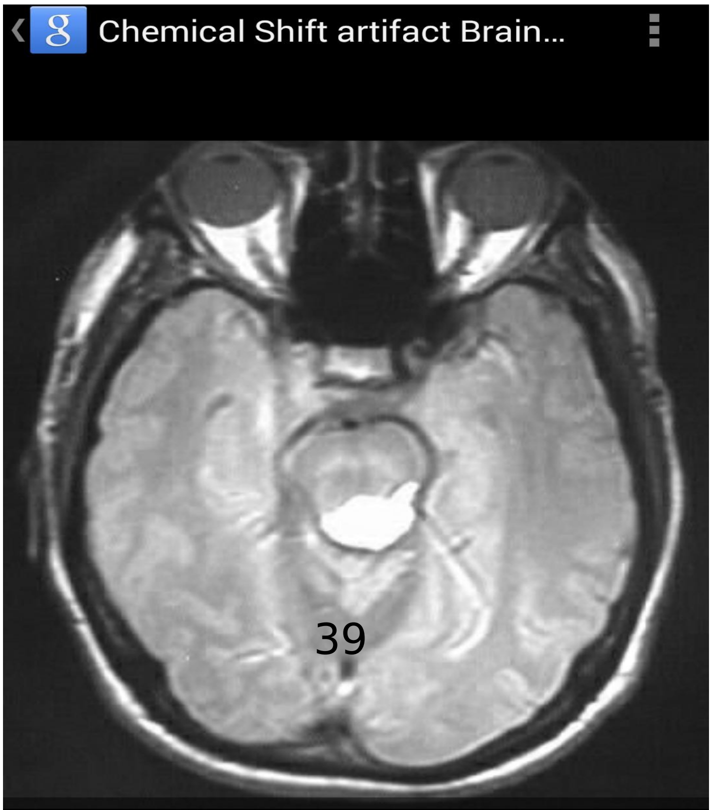

Figure: (2-4-1-4-1) coronal T1 with contrast showed (chemical misregistration artifact)(www.radiopaedia.org)

2.4.1.5 Truncation artifact

This artifact results from under sampling of data at the interface of high and low signal, which are incorrectly represented on the image.

· A common site for this artifact is in TI sagittal image of cervical spine, where there CSF and spinal cord (Gibbs artifact).

Occurs in phase direction.

· The truncation artifact appears as multiple rings of

regular periodicity or duplication at transitions between high

and low intensity signals.(Catherin west book et al , 1998)

2.4.1.5.1 The remedy of truncation

· Increase the number of phase in coding steps.

· For example, use 256 x 256 matrix instead of 256 x 128. (Catherin west book et al , 1998)

2.4.1.6 Zipper artifact

This artifact appears as a dense line on the image at a specific point. This is caused by extraneous RF entering the room at certain frequency, and interfering with the inherent weak signal coming from the patient. It is caused by a leak in the RF shielding of the room.

From extraneous radio noise on two different image sections from the same acquisition. .(Catherin west book et al , 1998)

2.4.1.6.1 The remedy of zipper artifact

· Call the engineer to locate the leak and repair it. .(Catherin west book et al , 1998)

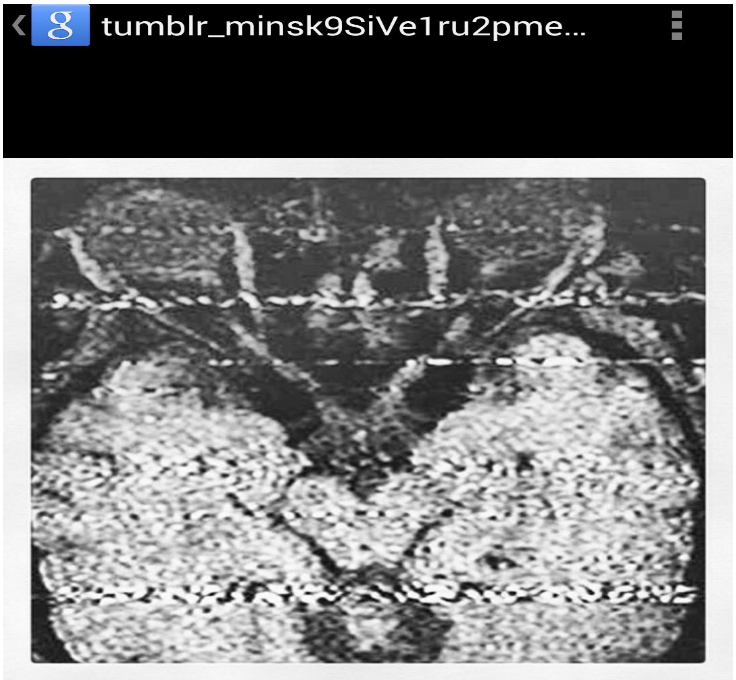

Figure (2.4.1.6.1)coronal T1 weight image of brain showed (zipper artifact artifact)

(www.rdiopaedia.org

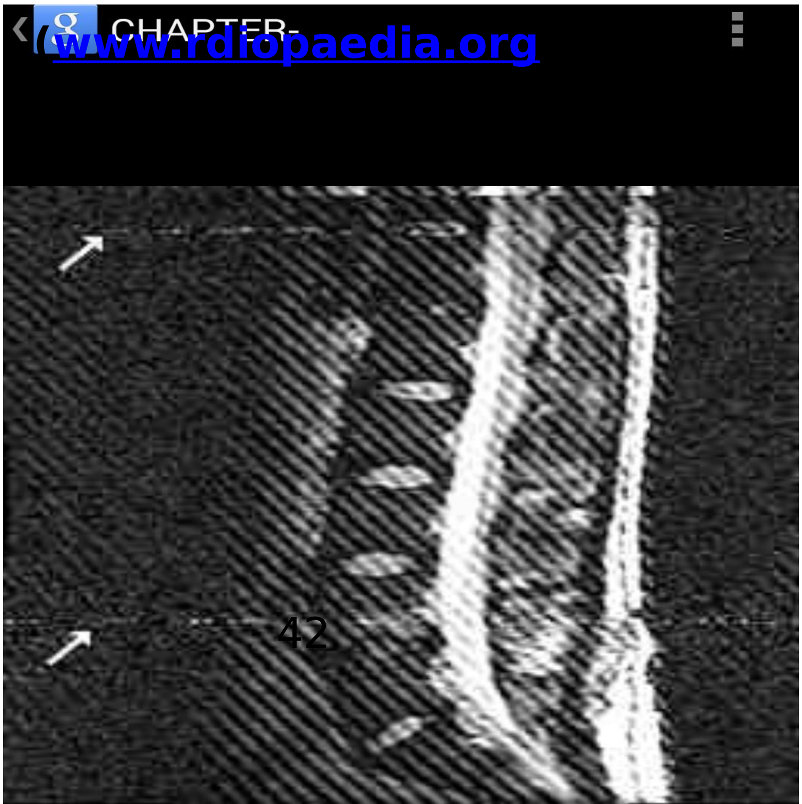

Figure (2.4.1.6.1) sagital T2 weigth image of lumber showed (zipper artifact) (www.radiopaedia.org)

2.4.1.7 Aliasing artifact (Wrap around)

Aliasing is an artifact produced when anatomy that exists

outside the F.O.V is mapped inside the F.O.V.

For example: On a midline sagittal brain MR image, the

patient nose may artifactually displayed over the area of

posterior fossa.

Aliasing can occur along both the frequency and phase axis.

The appearance is as though the image that was not properly

sampled has been folded over on to the opposite of the image.(Catherin west book et al , 1998)

2.4.1.7.1 Frequency wrap

Aliasing along the frequency encoding axis this is caused by

under sampling the frequencies that are present in the echo.

These frequencies originate form any signal.

Regardless of whether the anatomy producing it is inside or

out side the selected F.O.V. .(Catherin west book et al , 1998)

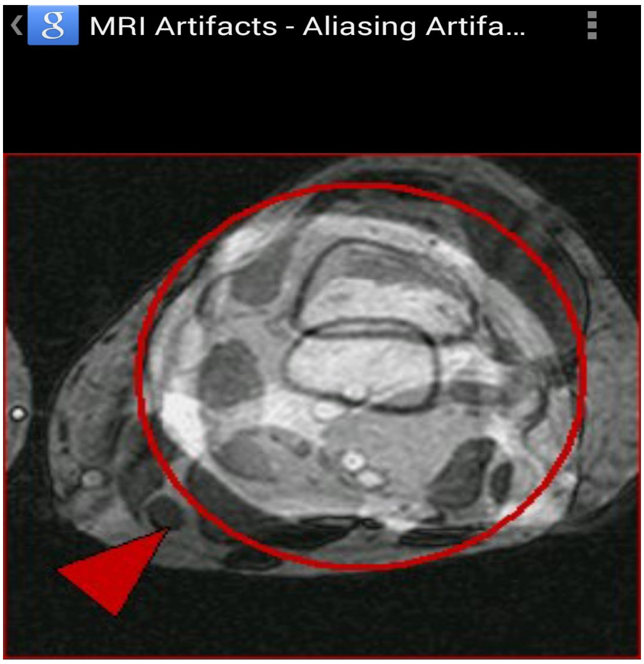

Figure (2.4.1.7.1) axiall T1weigth image of knee joint red arrow (Frequency wrap)(www.radiopadia.org)

2.4.1.7.2 Phase wrap

· Aliasing along the phase encoding axis. This is caused by

under sampling along the phase axis.

· Every phase value must be mapped into FOV in the phase

encoding direction.

Aliasing artifact.(Catherin west book et al , 1998)

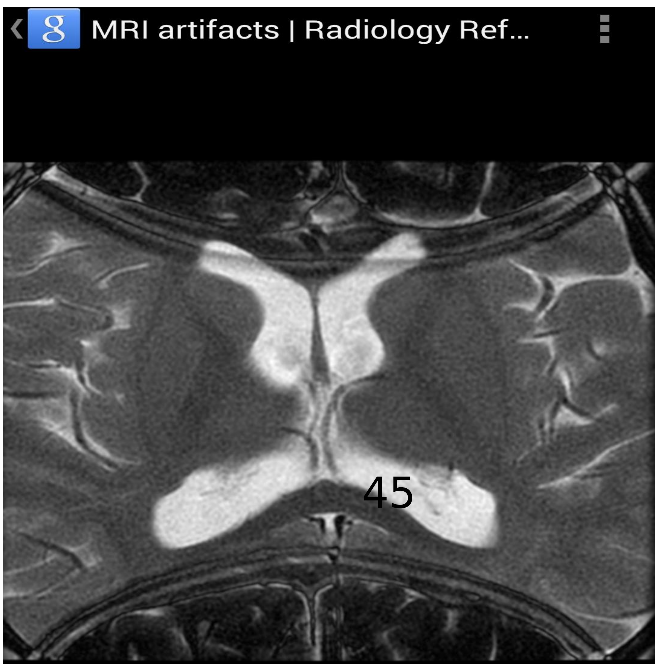

Figure (2.4.1.7.2)Axial T2image of brain showed(Phase wrap artifact)(www.radiopaedia.org)

2.4.1.7.3 Anti-aliasing

· Anti-aliasing along frequency axis:

Termed no frequency wrap uses digital RF pluses to cut off

signal frequencies at the edges of the F.O.V a long the

frequency axis. .(Catherin west book et al , 1998)

2.4.1.7.4 Anti-aliasing along the phase axis:-

Termed no phase wrap. No phase warp over samples along

the phase encoding axis by increase the number of phase

encoding axis by in creasing the number of phase encodings

perform. This done by enlarging the F.O.V.(Catherin west book et al , 1998)

.

2.4.1.8 Shading artifact

· Appears as a loss of signal intensity in one part of the image. Its main cause is uneven excitation of nuclei within the patient due to RF pulses applied at flip angles other than 90 degree and 180 degree.

· My occur with a large patients, who touches side of the body coil and couples it at that point.

· Can also be caused by in homogeneities in main magnetic field. .(Catherin west book et al,1998)

2.4.1.8.1 The remedy

· Always ensure that the coil is loaded correctly.

· Patient is not touching the coil at any point.

· Ensure that appropriate pre – scan parameters have been obtained before the scan, as these determine the correct exitation frequency and amplitude of applied RF pulses. .(Catherin west book et al , 1998)

2.4.1.9 Cross excitation and cross talk

· Energy given to nuclei in adjacent slices by the RF pulse, so that they become saturated when they themselves
are excited. The affect is produced by energy dissipation to
adjacent slices, as nuclei within the selected slice relax to
Bo.
Cross excitation and crosstalk affect image contrast. .(Catherin west book et al , 1998)

2.4.1.9.1 The remedy of cross excitation and cross talk :

· Ensuring that there is at least a 30% gap between slices.
· Squaring off the RF pulses by software. .(Catherin west book et al , 1998)

2.4.1.10 Motion of the patient :

Any motion of the patient causes artifact – motion is usually
either involuntary (twitching, pulsation, bowel motion) or
voluntary (swallowing, nervousness), and cause image degradation.

Motion artifacts are always propagated in the phase –
encoding direction. Random patient motion appears as a
blurring of the image. .(Catherin west book et al , 1998)

2.4.1.10.1 The remedy :

Involuntary motion can often be compensated for Bowel
motion can be reduced by giving the patient an anti –
spasmodic agent prior to the scan when imaging the abdomen
or pelvis.

· Pulsation can be reduced by the use of pre-saturation
gating or gradient moment nulling techniques.

Increasing NEX may also help, as this increases the number of
times the signal is averaged.

Motion artifact is averaged out of the image as it is more
random in nature than the signal itself.

·Voluntary motion can be reduced by making the patients as comfortable as possible and immobilizing
them with pads and straps.
A nervous patients always benefits from thoughtful explanation of the procedure, and a constant reminder
over the system inter come to keep still.
·A relative or friend in the room can also help in some
circumstances.
·In extreme cases, sedation of the patient may be required. .(Catherin west book et al , 1998)

figure (2.4.1.10) axiall T1weigth image of brain showed (Motion artifact)(www.radiopaedia.org)

2.5 Previous Study:

Found some previous study related to assessment of MRI image quality in Khartoum state. First Study about on MRI artifact of dental metallic material the MRI artifacts caused by three dental metallic material on thirteen MR sequences are studied. The sizes of the artifacts are measured and statistics analyses are performed.On the same sequence,the artifacts caused by titanium alloy are the smallest,and the artifacts caused by soft Co-Cr alloy are larger and by hard Co-Cr alloys are the largest.For the same alloy,the MRI artifacts in six spin echo sequences are the smallest,and in three gradient echo sequences are larger and in four echo planer sequences are the largest.Artifacts produced by oral metallic material are related with the type of the materials and the techniques of the imaging.The high quality MRI can be gained by using proper metallic material and choosing proper scan techniques. (《 Medical Equipment Journal》 2003-06)

Second study about Evaluation of quality control of MRI machines in Khartoum State, objective of this research evaluation of quality of MRI, the method is ISNR test, system uniformity, spatial resolution, and spatial linearity. The result of the research higher SNR and higher of linearity and uniformity in many center work on it. (ABdelkarim Eltayeb, 2011)

Third study about Artifacts in 3-T MRI: Physical background and reduction strategies, Magnetic resonance imaging (MRI) at a field-strength of 3 T has become more and more frequently used in recent years. In an increasing number of radiological sites, 3-T MRI now starts to play the same role for clinical imaging that was occupied by 1.5-T systems in the past. Because of physical limitations related to the higher field strength and because of protocols transferred from 1.5-T MRI that are not yet fully optimized for 3 T, radiologists and technicians working at these systems are relatively often confronted with image artifacts related to 3-T MRI. The purpose of this review article is to present the most relevant artifacts that arise in 3-T MRI, to provide some physical background on the formation of artifacts, and to suggest strategies to reduce or avoid these artifacts. The discussed artifacts are classified and ordered according to the physical mechanism or property of the MRI system responsible for their occurrence: artifacts caused by $B0$ inhomogeneity and susceptibility effects, $B1$ inhomogeneity and wavelength effects, chemical-shift effects, blood flow and magnetohydrodynamics, and artifacts related to SNR. (European Journal of Radiology Volume 65, Issue 1, January 2008)

Four study about Motion Artifact Suppression Technique (MAST) for MR Imaging. A technique has been developed that significantly improves the image resolution and reduces motion artifacts in conventional two-dimensional Fourier transform and three-dimensional Fourier transform magnetic resonance imaging sequences. Modifications on the gradient waveforms completely refocus the transverse magnetization at the echo time, regardless of the motion occurring between the time of the 90[degrees] radiofrequency excitation and the echo time (within-view). This accomplishes suppression of motion artifacts and regains the signal from flowing blood and CSF. Images of the head, abdomen, chest, and spine are reproduced which show the increase in signal and anatomical detail that would otherwise be degraded and lost in artifact noise. This technique has reduced the practical difficulty of obtaining clinically diagnostic T2-weighted abdominal images. It also has allowed diagnostic quality T1- and T2-weighted images to be obtained with one acquisition per view, thus reducing the total scan time. (Pattany, et al, 1987)

Five research about Magnetic resonance imaging with respiratory gating: techniques and advantages, Respiratory motion is an important problem in magnetic resonance imaging (MRI) of the thorax and upper abdomen. This study assessed several approaches for practical respiratory gating. Methods of acquiring respiratory signals, gated sequencing methods, duration of examination, strategies for reducing examination time, diagnostic quality of gated images, and the influence of respiratory gating on relaxation time measurements were evaluated. Of three different devices for acquiring the respiratory signal, a belt containing a displacement transducer placed around the upper abdomen was found to be most effective and practical. Two pulse-gating modes were implemented, as well as a method for combining cardiac and respiratory gating. Gating methods were tested using phantoms and human volunteers. A spin-conditioned mode of respiratory gating was found to be superior to a more simply implemented triggered mode in which spin-echo (SE) sequencing was interrupted. The time penalty for respiratory gating is technique-dependent. Gated studies with uncontrolled tidal breathing took two to four times longer than nongated studies. When the time between respirations was voluntarily prolonged, gated studies could be only 30%-50% longer than nongated. The standard deviation of relaxation-time measurements for organs that are displaced during respirations was substantially reduced by respiratory gating. Gating acquisition without spin-conditioning gating. Respiratory gating is a practical and useful technique for improving the contrast and spatial resolution of SE images of the upper abdomen and chest. SE images produced with short repetition times were particularly improved by respiratory gating. (RL Ehman, et al, 1984)

Chapter Three

Material & method

3- 1 Material

3-1-1 Machine

Center	Company	Magnet type	Magnet power
Asia	G Electric	Permanent	0.2 Tesla
Modern Medical center	G Electric	Superconducting	1.5 Tesla

3-1-2 Coil

- Type of coil in modern medical center all the type RF coil used in different type of the object.
- Type of the coil in Aisa also RF coil.

3-2 Method of data collection

3-2-1 data sheet

Data was collected By observation and recording of MR image details in data sheet has common artifacts by continuous visits to the MMC(MODEREN MEDICAL CENTER – ASI CENTER) from 15/9/2014 to 5/8/2015.

3-2-2 The interview:

interview for all radiographer who work in the 2 MR center (6 radiographer).

1) What type of artifacts done in your department and what is the reason?
2) What the treatment done when the artifact act?
3) When are you don’t repeated the artifact?

3-3 Data analysis:

observation static using statistic package (spss).

Chapter four

4-1 Result

The common artifacts which usually appear in concerned centers

Table (4-1) The average artifacts 6 month in the enters in table

The center	The average of case in week	The average of case in month	The average of artifacts in month	The probability of artifact per month
Asia	72	312	20	6.6
MMC	48	192	6	3.1

Table (4-2) Show the average of common artifact in MMC per month

Artifact	The average	Percentage
1. Motion	8	66.7%
2. Metallic	2	16.7%
3. Cross talk	0	0%
4. Shading	0	0%
5. Aliasing	1	8.3%
6. Phase wiap	0	0%
7. Frequency	0	0%
8. Zipper	1	8.3%
9. Truncation	0	0%
10. Chemical	0	0%
Total	**12**	**100%**

Fig (4-2)

table (4-3) Show the average of common artifact in Asia 6 month

Artifact	The average	Percentage
1. Motion	30	75%
2. Metallic	7	12.5%
3. Cross talk	0	2.5%
4. Shading	0	0%
5. Aliasing	0	2.5%
6. Phase wiap	0	0%
7. Frequency	0	0%
8. Zipper	3	7.5%
9. Truncation	0	0%
10. Chemical	0	0%
Total	**40**	**100%**

Fig (4-3)

Chapter Five

5-1 Discussion

the research done in Sudan to know and evaluate the image quality and the common artifacts in MR images in Khartoum State centers. Table(4-1) is showed calculator to the average artifacts 6 month in centers ,asia center include average of case per week 72, average of case per month 312 ,average of artifacts per month 20 ,probability of artifact per month6,6 ,modern meical center include average of case per week 48, average of case per month 192, average of artifacts per month 6 probability of artifact per month 3,1.

Table(4-2)The researcher found that in modern medical centre which has 1.5 tesla magnet, all the investigations of MRI are usually done specially chest, abdomen and MRA for brain and limbs, which they need physiological electro-cardiography respiratory unit (PERU), that mean the involuntary motion artifact reduced by high ration such as (respiratory, cardiac and peristaltic), but the voluntary motion is the still the problem causes artifact. Also all the types of coils are used in this center . From 12 artifacts collect per (3 month) was found that motion artifact has highest ration 66.7%, then metallic artifact 16.7%, zipper and aliasing has the same reading 8.3%, cross artifact has no reading, Table (4-2) Fig (4-2).

In Asia Hospital with 0.2 tesla from 40 artifact 75% were motion, 12.5 were metallic 7.5% were zipper and 2.5 were cross and aliasing, table (4-3) fig (4-3).

By distribution of the interview to the radiographer in the MR centers which their number is (6) radiographer, the findings of interview and analysis was 100% of the staff prove that the most common artifacts are motion, aliasing, zipper, metallic and cross artifact was metallic artifact .

Notice that most a cases does not usually done in this centre because a low power of magnet and the machine does not aids with the essential accessories such as respiratory, cardiac and peripheral gating).

This study associated with (American journal of roentagenology,1984) mention about repository gating technique. for motion artifact associated with (American jornal of rontagenology,1987)

In all centers most artifacts appear in the spine due to pulsatile movement of vessel heart and chest wall in dorsal spine.

Local oil in female's heir which contains a lot of iron is the important factor which caused ferromagnetic artifact.

Some of radiogrpher use fast spin echo, some use spin echo and others use gradient. when used first spin echo the ratio of artifact is reduced .this associaced with gad.lan,et al ,research mri artifact of dental metalic ,the research result high quality

MRI can be gained by using proper metallic material and choosing proper scan techniques.

From late analysis and result the probability of artifact in (Modern Medical Center) 1.5 tesla is 3.2 and (Asia hospital) 0.2 tesla 6.9.

That means there is direct relation between the magnetic power essential accessory of machine and the artifacts which appear in MR image and affect the quality. This associaced with OLP. stefan,et al research artifact in MRI 3t ;physcil background and reduction strategies. The research of (abdeelkarim eltayrb 2011) deffrent of method of research but associaced with my result .

5.2 Conclusion:

- The result of statistical analysis showed the same types of common artifacts in tow centers.
- -The most cases which has high ratio of artifact are abdomen, chest, spine and brain, 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 radiographer.
- Also, metallic artifacts, zipper, aliasing and cross the main factor to control them is the radiographer by his good skills and good instruction for the patients.
- -We found that motion artifact has highest ratio and it is the common artifact in MR centers in Khartoum state.
- -Flowed by metallic artifacts, and (Zipper-aliasing, cross) has the lowest reading.
- The Modern medical Center (1.5) Tesla superconductive magnet with ratio of artifact equal (3.2) is the leader in image quality because of high power magnet, the machine

supports by important accessories and skills of technologists which they all play important role to avoid and treat many types of artifacts. (table 4-1,4-2)

- Flowed by (Asia) hospital (0.2) Tesla and permanent magnet low power magnet (table 4-3).
- Noticed that most of motion artifact caused by children and old patients all artifacts usually happened are affect the diagnosis and lead to repeat the MR image.
- That means, update software and hardware which concerned with machine has good program to reduced number of artifacts in MR images.
- High power of magnet play main role in improves image quality.
- Accessories added to machines reduced the ratio of artifact such as (PERU).
- The 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

and case with head first like brain examination.

- There is a traffic artifact which affects the MR image, and fortunately found the MR examination rooms support with
- shielding to prevent RF coming from round traffic and position of MR room in the center of hospital departments.
- The rest of artifact has programs in software that reduced them.
- 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.
- These types of materials are pools, clips, and nails.

5.3 Recommendations:

- Good instruction and explanation should be given for the
- patient.
- The patients must be comfortable as possible and
- immobilizing them with pads and straps.
- MR machine must be supported by essential accessories
- (PEA R) such as (Respiratory compensation, cardiac and
- peripheral gating) to avoid involuntary motion.
- MR machine with magnetic power (1.5 to above) should
- be available in the centers.
- Continuous education should be held for Technologists.
- (FSE) pulse sequence must be used as standard technique.
- Technologists must take care to close the door of MR
- examination room tightly during the examination to prevent

- extraneous RF entering the room.
- The coils should be used according to the organs, and close the clips tightly during the preparation of the patient for examination.
- The patients who have a phobia to enter magnetic centre during examination, optical system must be used, in order to withdraw the idea of their staying in magnetic centre .in addition to head phone conducts with relax audio source.
- If the equipments mentioned above not offer, the patient should be anesthesia and supervised during examination.
- Most of the industrial company produced MR machines with wide centre and shallow cavity or like horse show, the Government must export machines like above.

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