بسم الله الرحمن الرحيم

Sudan University of Sciences and Technology

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Measurements of The Optic Nerve Diameter in Diabetic Patients using Magnetic Resonance Imaging

قياس العصب البصري لدى مرضى السكر باستخدام الرنين المغنطيسي

A Thesis Submitted for Partial Fulfillment of M.sc Degree in Diagnostic Radiologic Imaging

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Dedication

I dedicate this work to my parents, to my brothers and sisters

To my wonderful and lovely friends for their assistance, encouragement

and continues support.

Acknowledgements

First of all, I would like to express my deepest thanks to Allah who gave me health and power to do this research. Secondly, I want to show my gratitude to Dr. Asma Ibrahim Ahmed for her outstanding supervision and scientific continuous support throughout this research. Also many thanks to Dr. Ali Mohamed Abdelrazig for his constant guidance, encouragement and for sharing his valuable experience.

My sincere Thanks to all of my colleagues and friends in Radiology Departments in Dar Alelaj Specialized Hospital for their cooperation in collecting and providing a pleasant environment for my paper.

Last thing I would like to thank my family and friends for providing a pleasant environment for my research and to all people those were kindly and peacefully participating in my subjective experiments.

Abstract

Magnetic resonance imaging (MRI) is a spectroscopic imaging technique used in medical to produce images of the human body. MRI is one of the safety diagnostic procedures for measurement of the optic nerve diameter. The objective of this study is to measure the effectiveness of magnetic resonance imaging to measure the optic nerve affected by Diabetes. A total of 50 diabetic and control patients [30 (60%) diabetic patients, 20 (40%) control group]. The mean and range of patient age was 57.5 (30-85) years old.

The study found that in a comparison between males and females in the measurement of the optic nerve was insignificant (diabetes has no effect on gender). But when we compare between types of diabetic found that also imaging insignificant results. Whereas, comparison between diabetic patients and control group there was a significant different in measurements of the optic nerve. The patient age affect the optic nerve diameter in length and widths. The gender has no effect on the optic nerve diameter in diabetic patient.

This study was conducted in Daralelaj Specialized Hospital in the period from February 2018 to May 2018.

الملخص:

التصوير بالرنين المغناطيسي هو أحد تقنيات التصوير الطيفي المستخدمة في إنتاج الصور الطبية من داخل جسم الإنسان. وهو أحد وسائل التشخيص الآمنة لقياس قطر العصب البصري.

هدفت هذه الدراسة لمعرفة فعالية التصوير بالرنين المغناطيسي لقياس العصب البصري لمرض السكري، العدد الكلي للأشخاص هو 50، منهم [30 مريض بالسكري ونسبتهم (60 ٪) من العدد الكلي، و 20 سليمين من السكري ونسبتهم (40 ٪) من العدد الكلي]، وكان متوسط ومدى عمر المرضى هو 57.5 (30-85) سنة.

ووجدت الدراسة أن المقارنة بين الذكور والإناث في قياس العصب البصري غير مهم (لم يكن للسكري أي تأثير على الجنس)، وعند المقارنة بين أنواع مرض السكري وجدت الدراسة أن لهذه القياسات النتائج أيضا غير ذات دلالة. ولكن عند المقارنة بين مرضى السكري والمجموعة السليمة من السكري كان هناك اختلاف كبير في قياسات العصب البصري.

ووجد أن عمر المريض يؤثرعلى قطر العصب البصري في الطول والعرض. أما الجنس ليس له أي تأثير على قطر العصب البصري في مريض السكري وأجريت هذه الدراسة في مستشفى دارالعلاج التخصصي في الفترة من فبراير 2018 وحتى مايو 2018.

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List of Abbreviations

MRI	Magnetic Resonance Imaging
SNR	Signal to Noise Ratio
STIR	Short tau Inversion Recovery
FLAIR	Fluid-Attenuated Inversion Recovery
DWI	Diffusion-Weighted Imaging
DME	Diabetic Macular Edema
DP	Diabetic Papillopathy
SWI	Susceptibility-Weighted Imaging
APD	Afferent Papillary Defects
AION	Anterior Ischemic Optic Neuropathy
NAION	Non-Arteritic Ischemic Optic Neuropathy
NMR	Nuclear Magnetic Resonance
RF	Radio Frequency
ONS	Optic Nerve Sheath
CT	Computed Tomography
ONSD	Optic nerve sheath diameter
OND	Optic nerve diameter
SD	Standard deviation
DKA	Diabetes with ketoacidosis

Chapter One

Introduction

Chapter One

Introduction

1.1 Introduction

The optic nerve is the sensory nerve of the retina. Its fibers originate in the ganglion layer and converge on the posterior part of the eye ball. The nerve passes backwards through the orbit and optic canal into the middle cranial fossa where it unites with the nerve of opposite side of the optic chiasm. Diabetes is a common cause of damage to the optic nerve. It is a condition where the body's incapable of correctly processing and using sugar. The body's incapable of metabolizing sugars properly, resulting in high levels of glucose within the blood. When left untreated for prolonged periods, blindness can result from damage to the optic nerve. Blurred vision usually occurs prior to complete vision loss in diabetic patients. MRI has a great value in measurements of the optic nerve and optic chiasm in diabetic patients. [Welsely, 2003]

Apart from clinical and ophthalmoscopic evaluation, imaging, especially magnetic resonance imaging (MRI), plays an important role in the complete evaluation of optic nerve and the entire visual pathway. In this pictorial essay, the authors describe segmental anatomy of the optic nerve and review the imaging findings of various conditions affecting the optic nerves. The various common pathologies affecting optic nerves, such as demyelinating and inflammatory processes to less common optic nerve tumors and very rare congenital optic nerve abnormalities. Magnetic resonance imaging (MRI) is extremely useful in promptly identifying some of these pathologies to avoid permanent visual loss. In some cases, especially hereditary and congenital pathologies, unnecessary additional work-up can be avoided as it helps in better counseling of patients and their families. [Gala 2015].

1.2 Problem of the study:

Diabetic can affect human being health which usually affects optic nerve disorder early diagnosis of this abnormality decreased damage.

1.3 Objectives:

1.3.1 General Objective:

To measure the optic nerve in diabetic pation

1.3.2 Specific Objectives:

- To measure the optic nerve diameter in coronal and sagital MRI images.
- To compare the findings with control group.
- To assess patient age, gender and duration of diabetes.
- To correlate the findings with diabetes type.

1.4 Thesis arrangement:

Chapter one represents introduction, chapter two deals with literature review and previous studies, chapter three illustrates methodology (materials and methods of the study), and chapter four represents results. Whereas chapter five deals with Discussions, conclusion and recommendations. Finally there are references and appendices.

Chapter Two

Literature Review

Chapter Two

Literature Review

2.1 Anatomy of the Eye:

There are three layers of tissue from the eye ball: the sclera, the choroids and the retina. The outer layer of sclera consists of though fibrous tissue. The white of the eye is part of the front surface of the sclera. The other part of the front surface of the sclera is called the cornea and is sometimes described as the window of the eye because of its transparency. At casual glance however it does not look transparent but appears blue, brown, gray or green because it lies over the iris, the colored part of the eye. A mucous membrane known as the conjunctiva lines the eyelids and covers the sclera in front. The conjunctiva is kept moist by tears formed in the lacrimal gland located in the upper lateral portion of the orbit. The middle layer of the eyeball, the choroid, contains a dark pigment to prevent the scattering of incoming light rays. Two involuntary muscles make up the front part of the choroids. One is the iris, the colored structure seen through the cornea and the other is the ciliary muscle. [www.visualhealthsolutions.com]

The black center of the iris is really a hole in this doughnut-shape muscle it is pupil of the eye. Some of the fibers of the iris are arranged like spokes in a wheel. When they contract the pupils dilate, letting in more light rays. Other fibers are circular. When they contract, the pupils Constrict letting fewer light rays. Normally the pupils constrict in bright light and dilate in dim light. When we look at distant objects, the ciliary muscle is relaxed and the lens has only a slightly curved shape to focus on near objects however, the ciliary muscle contract. [Encyclopedia Britannica 2015]

As it contracts, it pulls the choroids coat forward toward the lens, thus causing the lens to bulge and curve even more. Most of us become more farsighted as we grow older and lose the ability to focus on close objects

because our lenses lose their elasticity and con no longer bulge enough to bring near objects into focus. Presbyopia or old sightedness is the name for this condition. The retina or innermost layer of the eyeball contains microscopic receptor cells, called rods and cones because of their shapes. Dim light can stimulate the rods, but fairly bright light is necessary to stimulate the cones. In other words, rods are the receptors for night vision and cones for day time vision. There are three kinds of cones; each is sensitive to a different color: red, green, or blue. Scattered throughout the central portion of the retina, these three types of cones allow us to distinguish between different colors. [www.visualhealthsolutions.com]

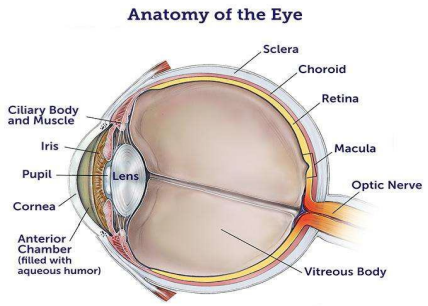

Figure 2.1 shows anatomy of the eye [Human anatomy 2014]

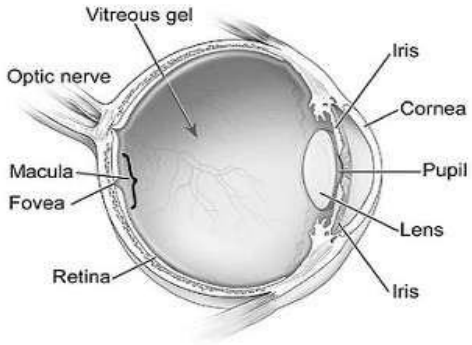

Figure 2.2 shows anatomy of the eye [Michael 1989]

2.1.1 The Optic Nerve:

The optic nerve is located in the back of the eye. It is also called the second cranial nerve or cranial nerve II**.** It is the second of several pairs of cranial nerves. The job of the optic nerve is to transfer visual information from the retina to the vision centers of the brain via electrical impulses.

The optic nerve is made of ganglionic cells or nerve cells. It consists of over one million nerve fibers. Our blind spot is caused by the absence of specialized photosensitive (light-sensitive) cells, or photoreceptors, in the part of the retina where the optic nerve exits the eye. [Encyclopedia Britannica 2015]

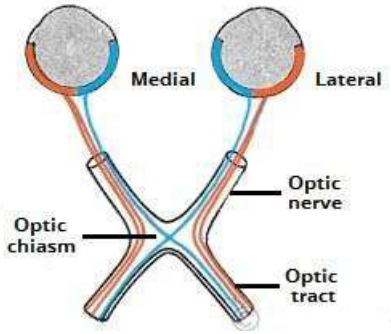

Figure 2.3 shows the optic nerve [Vilensky et al 2015]

2.1.2 Visual pathway:

The axons of the ganglion cells converge on the region of the retina called the papilla or optic disk. They leave the globe as the optic nerve, in which they maintain an orderly arrangement in the sense that fibers from the macular zone of the retina occupy the central portion, the fibers from the temporal half of the retina take up a concentric position, and so on; when outside the orbit, there is a partial decussating (crossover). The fibers from the nasal halves of each retina cross to the opposite side of the brain, while those from the temporal halves remain uncrossed. This partial decussation is called the chiasm. The optic nerves after this point are called the optic tracts, containing nerve fibers from both retinas. The result of the partial

decussation is that an object in, say, the right-hand visual field produces effects in the two eyes that are transmitted to the left-hand side of the brain only. With cutaneous (skin) sensation there is a complete crossing-over of the sensory pathway; thus, information from the right half of the body, and the right visual field, is all conveyed to the left-hand part of the brain by the time that it has reached the diencephalon (the posterior part of the forebrain). [Helga 2011]

2.1.3 Blind spot:

The beginning of the optic nerve in the retina is called the optic nerve head or optic disc. Since there are no photoreceptors (cones and rods) in the optic nerve head, this area of the retina cannot respond to light stimulation. As a result, it is known as the "blind spot," and everybody has one in each eye. The reason we normally do not notice our blind spots is because, when both eyes are open, the blind spot of one eye corresponds to retina that is seeing properly in the other eye. [Perkind et al 2018]

2.1.4 The Retina:

The retina is a complex transparent tissue consisting of several layers, only one of which contains light-sensitive photoreceptor cells. Light must pass through the overlying layers to reach the photoreceptor cells, which are of two types, rods and cones, which are differentiated structurally by their distinctive shapes and functionally by their sensitivity to different kinds of light. Rods predominate in nocturnal animals and are most sensitive to reduced light intensities; in humans they provide night vision and aid in visual orientation. [Helga 2011]

Cones are more prominent in humans and those animals that are active during the day and provide detailed vision (as for reading) and color perception. In general, the more cones per unit area of retina, the finer the detail that can be discriminated by that area. Rods are fairly well distributed

over the entire retina, but cones tend to concentrate at two sites: the fovea centralis, a pit at the rear of the retina, which contains no rods and has the densest concentration of cones in the eye, and the surrounding macula lutea, a circular patch of yellow-pigmented tissue about 5 to 6 mm (0.2 to 0.24 inch) in diameter. When light enters the eye, it passes through the cornea and the lens and is refracted, focusing an image onto the retina. Light-sensitive molecules in the rods and cones react to specific wavelengths of light and trigger nerve impulses. Complex interconnections (synapses) between and within retinal cell layers assemble these impulses into a coherent pattern, which in turn is carried through the optic nerve to the visual centers of the brain, where they are further organized and interpreted. [Helga 2011]

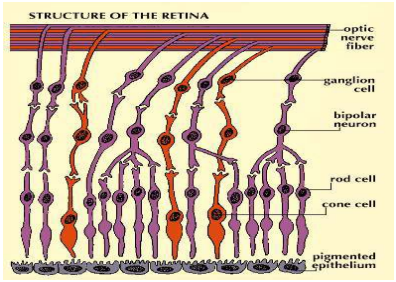

Figure 2.4 shows the retina [Michael 2012]

2.2 Physiology of the Eye:

2.2.1 Process of vision:

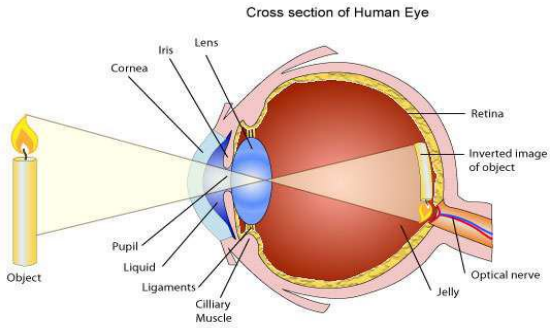

Figure 2.5 show the process of vision [Geoffrey et al 2006]

Light waves from an object (such as a tree) enter the eye first through the cornea, which is the clear dome at the front of the eye. It is like a window

that allows light to enter the eye. The light then progresses through the pupil, the circular opening in the center of the colored iris.

Fluctuations in the intensity of incoming light change the size of the eye's pupil. As the light entering the eye becomes brighter, the pupil will constrict (get smaller), due to the papillary light response As the entering light becomes dimmer, the pupil will dilate (get larger).Initially, the light waves are bent or converged first by the cornea, and then further by the crystalline lens (located immediately behind the iris and the pupil), to a nodal point (N) located immediately behind the back surface of the lens. At that point, the image becomes reversed (turned backwards) and inverted (turned upside-down). [Gary 2012]

The light continues through the vitreous humor, the clear gel that makes up about 80% of the eye's volume and then, ideally, back to a clear focus on the retina, behind the vitreous. The small central area of the retina is the macula, which provides the best vision of any location in the retina. If the eye is considered to be a type of camera (albeit, an extremely complex one), the retina is equivalent to the film inside of the camera, registering the tiny photons of light interacting with it. Within the layers of the retina, light impulses are changed into electrical signals. Then they are sent through the optic nerve, along the visual pathway, to the occipital cortex at the posterior (back) of the brain. Here, the electrical signals are interpreted or "seen" by the brain as a visual image. [Gary 2012]

2.3 Pathology:

2.3.1 Diabetes mellitus:

A disease in which the body's ability to produce or respond to the hormone insulin is impaired, resulting in abnormal metabolism of carbohydrates and elevated levels of glucose in the blood and urine. [Perkind et al 2018]

2.3.1.1 Type 1 diabetes

Type **1**diabetes is an autoimmune condition. It is used to be called insulin dependent diabetes and is caused by the body attacking its own pancreas with antibodies. In people with type 1 diabetes, the damaged pancreas doesn't make insulin. This type of diabetes may be caused by a genetic predisposition. It could also be the result of faulty beta cells in the pancreas that normally produce insulin. [www.webmd.com/diabetes2017]

2.3.1.1.1 Signs and symptoms:

Increased urinary frequency (polyuria), thirst (polydipsia), hunger (polyphagia) and unexplained weight loss, numbness in extremities, pain in feet (disesthesias), fatigue and blurred vision, recurrent or severe infections, and loss of consciousness or severe nausea/vomiting. (ketoacidosis) or coma. Ketoacidosis more common in T1D than in T2D. [National Eye institute]

2.3.1.2 Type 2 diabetes

Occurs when the body doesn't produce enough insulin to function properly, or the body's cells don't react to insulin. This means glucose stays in the blood and isn't used as fuel for energy. Type 2diabetes is often associated with obesity and tends to be diagnosed in older people. It's far more common than type 1 diabetes. [Kronenberg 2011]

2.3.1.2.1 Signs and symptoms:

Patients may have no symptoms at all or minimal symptoms for years before being diagnosed, also may have increased urinary frequency (polyuria), thirst (polydipsia), hunger (polyphagia) and unexplained weight loss, experience numbness in extremities, pain in feet (disesthesias) and blurred vision, have recurrent or severe infections, and patients may present with loss of consciousness or coma but this is less common than in T1D. [National Eye institute]

2.3.1.3 The Causes:

The Causes Feature Comparison of type 1 and 2 diabetes

Table 2.1 shows comparison between diabetes types [Cefalu 2002]

Comparison of type 1 and 2 diabetes		
Feature	**Type 1 diabetes**	**Type 2 diabetes**
Onset	Sudden	Gradual
Age at onset	Mostly in children	Mostly in adults
Body size	Thin or normal	Often obese
Ketoacidosis	Common	Rare
Autoantibodies	Usually present	Absent
Endogenous insulin	Low or absent	Normal, decreased
Concordance in identical twins	50%	90%

2.3.1.4 Complications of diabetes mellitus

In patients with diabetes mellitus, years of poorly controlled hyperglycemia lead to multiple, primarily vascular, complications that affect small vessels (microvascular), large vessels (macrovascular), or both .The mechanisms by which vascular disease develops include: glycosylation of serum and tissue proteins with formation of advanced glycation end products, superoxide production, activation of protein kinase C, a signaling molecule that increases vascular permeability and causes endothelial dysfunction, accelerated hexosamine biosynthetic and polyol pathways leading to sorbitol accumulation within tissues, hypertension and dyslipidemias that commonly accompany diabetes mellitus, arterial microthromboses, proinflammatory and prothrombotic effects of hyperglycemia and hyperinsulinemia that impair vascular autoregulation. Immune dysfunction is another major

complication and develops from the direct effects of hyperglycemia on cellular immunity. [Lagle et al 2012]

2.3.2 The effect of diabetes on eyes:

Diabetic eye disease is a group of eye conditions that can affect people with diabetes. Diabetic retinopathy affects blood vessels in the light-sensitive tissue called the retina that lines the back of the eye. It is the most common cause of vision loss among people with diabetes and the leading cause of vision impairment and blindness among working age adults. Diabetic macular edema (DME). A consequence of diabetic retinopathy, DME is swelling in an area of the retina called the macula. [Jeganathan et al 2008]

2.3.3 The effect of diabetes on optic nerve:

2.3.3.1 Diabetic Papillopathy:

Diabetic papillopathy (DP) is characterized by optic disc edema but an absence of optic nerve dysfunction, normal intracranial pressure, a lack of nerve inflammation, infiltration or infection and no afferent papillary defects (APD) or dyschromatopsia. [Opara 2005]

2.3.3.2 Anterior Ischemic Optic Neuropathy:

Anterior ischemic optic neuropathy (AION) is clinically classified as an acute, pallid optic disc swelling (followed by optic nerve pallor) with APD associated with visual field defects telangiectasia of disc vessels may occur, which may be mistaken for disc neovascularization. AION is thought to be precipitated by circulatory insufficiency in nonarteritic ischemic optic neuropathy (NAION). Diabetic patients are at increased risk of developing NAION. [Carlvon 2001]

2.4 History of Medical Imaging

Medical imaging began in November 1895 with Wilhelm Conrad Roentgen's discovery of the X-ray. Working with an early cathode ray tube called a

Crooke's tube, he noticed that the invisible rays were able to penetrate some solids (like human flesh) better than others (like bone or metal). He confined himself to his basement laboratory in Würzburg, Germany, for six weeks while Frau Roentgen brought him meals. During that time he discovered most of what the world would know about X-rays for the next twenty years. For his efforts he was awarded the first Nobel Prize in 1901. [Bradley 2015].

As the X-ray beam became more powerful, patient motion could be visualized and "fluoroscopy" became possible. Fluoroscopy is still in common use today, but it has advanced considerably. Today, with modern image intensifies, that is no longer necessary. In addition, many of the diseases initially diagnosed by fluoroscopy are now diagnosed by computed tomography. X-ray tomography was introduced in the 1940s, allowing "tomograms" or slices to be obtained through tissues without the over- or under-lying tissue's being seen. [Bradley 2015]

Both CT and MRI are tomographic techniques that display the anatomy in slices rather than through and through projections (like an X-ray) procedures. In the 1950s nuclear medicine entered our armamentarium of diagnostic imaging tests. In these tests, the source of the X-rays is not an X-ray tube but rather radioactive compounds, which typically emit gamma rays as they decay. They are combined with other compounds that are taken up as part of the disease process to study a particular problem. For example, Technetium 99m can be combined with méthylène diphosphonate, which is taken up by bone being invaded by a tumor. So, for example, cancer of the breast or lung, which tends to spread ("metastasize") to the bones can be easily detected by such a nuclear bone scan. Ultrasound was first used clinically in the 1970s. Unlike X-ray and nuclear medicine, ultrasound uses no ionizing radiation - just sound waves. [Bradley 2015]

As the sound waves pass through the tissue and are reflected back, tomographic images can be created and tissues can be characterized. For

example, a mass found on a mammogram can be further characterized as solid (possibly cancer) or cystic (most likely benign). Ultrasound is also useful for the noninvasive imaging of the abdomen and pelvis, including imaging the fetus during pregnancy. Today ultrasound can be performed by a portable unit no larger than a laptop computer. X-ray is also the basis of mammography, which is a dedicated system that takes high-resolution images of the breasts, looking for breast cancer. Over the years, the X-ray dose of the mammograms has decreased, making the examination safe. [Bradley 2015]

Computers really entered the world of medical imaging in the early 1970s with the advent of computed tomography (CT scanning) and then magnetic resonance imaging (MRI). CT was a major advance that first allowed multiple tomographic images (slices) of the brain to be acquired. n. In CT an X-ray tube rotates around the patient and various detectors pick up the X-rays that are not absorbed, reflected, or refracted as they pass through the body. MRI also evolved during the 1970s, initially on resistive magnets with weak magnetic fields, producing images with low spatial resolution. Even then, however, it was obvious that the soft tissue discrimination of MRI was superior to that of CT, allowing earlier diagnoses. MR also had the advantage that it did not require ionizing radiation like X-ray based CT. Over the 1980s and 1990s, superconducting magnets became common, initially at 1.5 Tesla and now at 3 Tesla. (Tesla is a measure of magnetic field strength. The earth's magnetic field, for example, is 0.00005 Tesla. Thus a 1.5 T magnet has field strength 30,000 times stronger than that of the earth). [Bradley 2015]

2.4.1 MRI

Magnetic resonance imaging (MRI) is a spectroscopic imaging technique used in medical settings to produce images of the inside of the human body.

MRI is based on the principles of nuclear magnetic resonanec (NMR), which is a spectroscopic technique used to obtain microscopic chemical and physical data about molecules n In 1977 the first MRI exam was performed on a human being. It took 5 hours to produce one image.
[http://www.desy.de/~garutti/LECTURES/BioMedical/Lecture12_MRI.pdf**]**

2.4.1.1 MRI Physics

The magnetic resonance imaging is accomplished through the absorption and emission of energy of the radio frequency (RF) range of the electromagnetic spectrum. MRI utilizes non ionizing radiation (unlike x-rays), it has ability to image in any plane (unlike CT scans), also it has very low incidents of side effects, and it has ability to diagnose, visualize, and evaluate various illnesses as well as it is only better way to see the insides of your body is to cut you open. It composes from a magnet which produces a very powerful uniform magnetic field, gradient magnets which are much lower in strength, equipment to transmit radio frequency (RF), and a very powerful computer system, which translates the signals transmitted by the coils. The most important component of the MRI scanner is the magnet; the magnets currently used in scanners today are in the 0.5-tesla to 2.0-tesla range (5,000 to 20,000- gauss). Higher values are used for research, earth magnetic field: 0.5 gauss. There are three types of magnets used in MRI systems: resistive magnets, permanent magnets, and super conducting magnets (the most commonly used type in MRI scanners). In addition to the main magnet, the MRI machine also contains three gradient magnets. These magnets have a much lower magnetic field and are used to create a variable field. [http://www.desy.de/~garutti/LECTURES/BioMedical/Lecture12_MRI.pdf]

2.4.1.2 MRI Technique

In spin, the atoms that compose the human body have a property known as spin (a fundamental property of all atoms in nature like mass or charge).

Spin can be thought of as a small magnetic field and can be given a + or – sign and a mathematical value of multiples of ½. Components of an atom such as protons, electrons and neutrons all have spin. Protons and neutron spins are known as nuclear spins, an unpaired component has a spin of ½ and two particles with opposite spins cancel one another. In NMR it is the unpaired nuclear spins that produce a signal in a magnetic field. Human body is mainly composed of fat and water, which makes the human body, composed of about 63% hydrogen. The protons' important to MRI; because positively charged, spin about a central axis, a moving (spinning) charge creates a magnetic field, and the straight arrow (vector) indicates the direction of the magnetic field. When placed in a large magnetic field, hydrogen atoms have a strong tendency to align in the direction of the magnetic filed n Inside the bore of the scanner, the magnetic field runs down the center of the tube in which the patient is placed, so the hydrogen protons will line up in either the direction of the feet or the head. The majority will cancel each other, but the net number of protons is sufficient to produce an image. In energy absorption; the MRI machine applies radio frequency (RF) pulse that is specific to hydrogen and the RF pulses are applied through a coil that is specific to the part of the body being scanned. In resonance; the gradient magnets are rapidly turned on and off which alters the main magnetic field, and the pulse directed to a specific area of the body causes the protons to absorb energy and spin in different direction, which is known as resonance Frequency (Hz) of energy absorption depends on strength of external magnetic field. In imaging when the RF pulse is turned off; the hydrogen protons slowly return to their natural alignment within the magnetic field and release their excess stored energy, this is known as relaxation. ≥ two time-scales. [http://www.desy.de/~garutti**]**

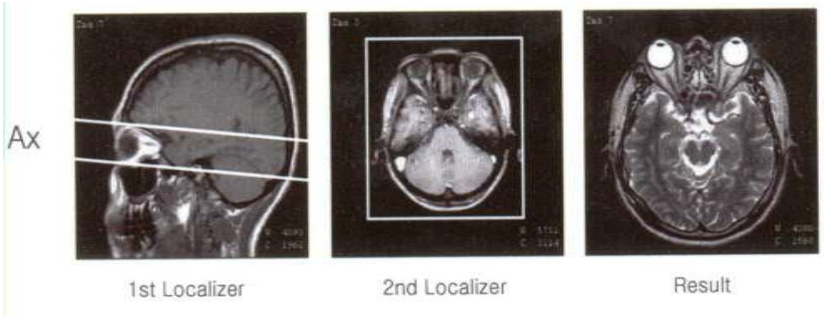

Fig.3.1 shows the Axial scan [Westbrook, 2008]

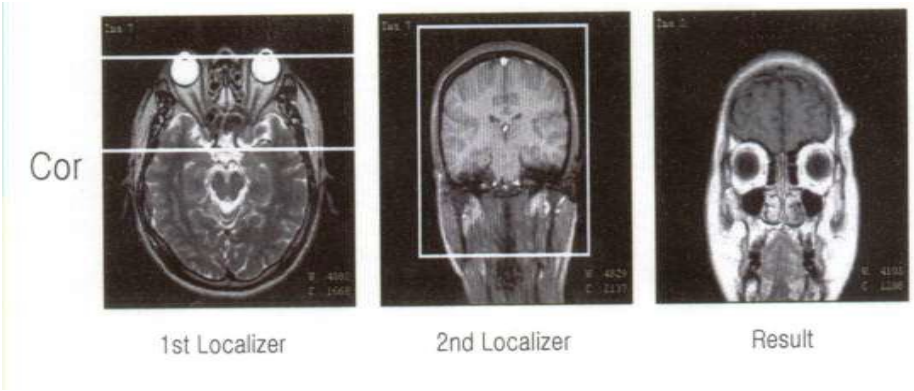

Fig. 3.2 shows the Sagittal scan [Westbrook, 2008]

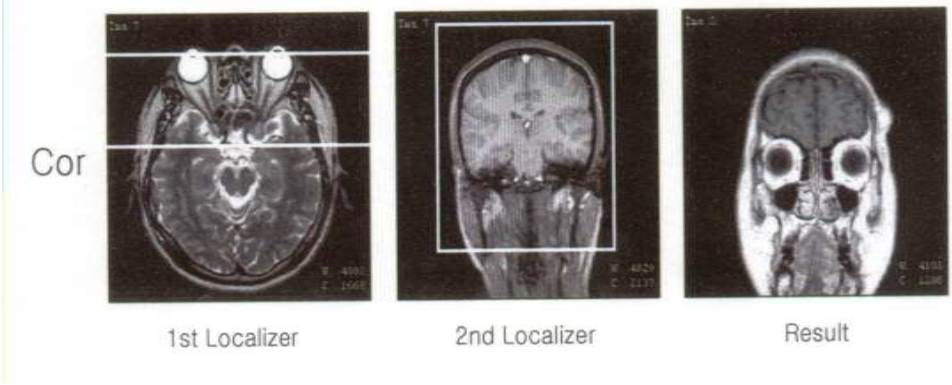

Fig 3.3 shows the Coronal scan [Westbrook 2008]

2.5 Previous Studies:

Measurements of the optic nerve diameter in diabetic patients by using MRI is a research area where different results were determined and ideas were recommended to achieve the MRI techniques principle has been studied by several researchers; for example; Benevento et al 2004 they aimed to determine the range of optic nerve diameters in normal human eyes using MRI coronal scans. They used MRI images of 14 Radiology patients who had undergone MRI of the face or brains for non–ophthalmologic reasons were retrospectively evaluated. Using T1 and T2 weighted coronal scans, the shortest apparent measurement of ONSD and OND were measured 3mm behind the globe by consensus opinion of two investigators. They found that the mean ONSD was 5.0mm in males SD 0.6mm, and 4.9mm SD 0.5mm in females. Mean ONSD was 4.9mm SD 0.6mm in subjects younger than 50 years old, and 5.0mm SD 0.5mm in subjects 50 and over. Mean OND was 3.1mm (range: 2.6 – 4.0) SD 0.3mm. Mean OND was 3.1mm in males SD 0.2mm, and 3.1mm SD 0.5mm in females. Mean OND was 3.3mm SD 0.4mm in subjects younger than 50 years old, and 3.0mm SD 0.3mm in subjects 50 and over. they concluded that the coronal MRI imaging of normal human eyes showed an average ONSD range of 4.0 – 6.0 with SD 0.5mm, and an average OND range of 2.6 – 4.0 with SD 0.3mm. Our range is consistent with published data on the ONSD. However, we are not aware of any published data on the OND. More precise measurements may be possible using dedicated multi–plane high resolution MRI images from larger sample size normal volunteers.

Blehar et al 2008 they aimed to compare visual axis measurements of the optic nerve sheath (ONS) with traditional coronal axis measurements to

assess for correlation. The ONS was visualized in 2 views on both eyes of healthy volunteers using an 8.5-MHz probe. Coronal axis views were obtained with the probe placed at the lateral canthus directed nasally posterior to the globe. Subsequent imaging was made along the midline visual axis. The diameter in this view was measured at several points posterior to the sclera (2, 3, 6, 9, 12, and 15 mm). Twenty-seven subjects were enrolled (54 scans). There was a significant difference between ONSDs measured in each axis, with a coronal axis mean diameter of 3.4 mm and visual axis mean diameters at 2, 3, 6, 9, 12, and 15 mm of 4.28, 4.32, 5.15, 5.74, 6.39, and 7.42 mm, respectively. The Pearson coefficient showed no correlation between coronal axis and visual axis measurements, with R values ranging from 0.51 to 0.69. There was a statistically significant increase in the ONSD as the nerve coursed posteriorly when measured in the visual axis. Visual axis measurements do not reliably correlate with coronal axis measurements. The consistently larger diameter measured in the visual axis as well as the gradually increasing diameter posteriorly suggests measurement of an artifactual shadow rather than the true ONS.

Hansen et al recently studied seven children with DKA at various time points and noted that, although no significant difference in effect size, three out of seven patients developed ONSD measurements changes ≥0.3 mm during treatment.32 Although we did not compare ONSD values to direct measures of ICP in our study, cerebrospinal fluid pressure may not have been high enough at our data collection point to produce significant ONSD changes reflective of subclinical DKA-CE. Several aspects of our study are worth further mention. While previous research suggested that IV fluid replacement may precipitate DKA-CE, recent investigation has shown that the rate and volume of IV fluid may not substantially contribute. In our study, both treatment groups received ≤10 ml/kg of IV fluid prior to transfer,

with no difference in total IV fluid amount received. Although time from IV fluid administration to ultrasound was significantly different between groups, we believe this likely reflects the difficulties in obtaining IV access in severely ill children, which is supported by our finding that percent dehydration was higher among those with DKA. Moreover, ONSD values were not affected by IV fluid amount, time from IV fluid administration to ultrasound, length of symptoms, or other known DKA-CE risk factors in our regression model. It should be noted, however, that our study was powered for our primary outcome to detect a difference in mean ONSD rather than multiple regression. A post-hoc power analysis of our regression model, with nine predictor variables and an observed R^2 of 0.39, demonstrated an observed power of 0.63. There were a higher proportion of African-American patients with DKA in our sample compared to White or Hispanic patients. Although this difference was not statistically significant, this may represent a clinically significant difference and is in keeping with recent literature showing that African-American children with T1D experience poorer glycemic control and more episodes of DKA compared to White or Hispanic children. Finally, although DKA-CE is more common in younger children, 1,54 we excluded patients <7 years for assent purposes.

Chapter Three

Materials and Methods

Chapter Three

Materials and Methods

3.1 Material:

3.1.1 Study Population:

50 Patients were examined [30 of them had diabetes (15 Male & 15 Female), 20 as control croup (12 Male & 8 Female)], and their ages range between 30 – 90 years old all of them did MRI orbits. The study has been carried out in Khartoum state during the period from February 2018 to May 2018**.** In Dar Alelaj Specialized Hospital, Khartoum State.

3.1.2 Machine

Philips 1.5 Tesla Gradient options performance values, performance TQ System type Trio Max. Gradient field (X/Y/Z) 40/40/45 mT/m Min. rise time 200 μse c.(0 - 40 mT/m)Slew rate200 T/m/s Max. Gradient current 625 A Max voltage (across Gradient Coil) 2000 V Gradient Coil AS 092[Philips ingenia products corporation .inc]

3.2 Methods

The patient lies supine on the examination couch. Both orbits are examined. Used head coil, these are placed over-each orbit but should not touch the patient. The patients are positioned so that the longitudinal alignment light lies in the midline and the horizontal alignment light passes through the orbits. Straps and foam pads are used for immobilization.

3.2.1 Technique

1. Axial SE T1
2. Coronal SE T1
3. Sagittal SE T1

Sagittal oblique T**2** Tr 5000 Te 105 for the length.

Coronal T**2** Tr 5000 Te 105 for the widths.

Small surface coil for globe and orbit, quadrature head coil for orbital apex, Immobilization straps and foam pads.

3.2.2 Image measurement

By measuring the length of the optic nerve (the area from the posterior part of the eye ball to the optic chiasm) and the area between the two borders of optic canal (widths of the optic nerve).

3.2.3 Statistic method

All patient demographic data and measurement parameters were analyzed using Excel 2013 and SPSS version 20 method for data analysis. The necessary statistical measures were applied to assess the results.

3.2.4 Ethical Considerations

- Written ethical clearance and approval for conducting this research was obtained from an administration of Dar Alelaj Specialized Hospital.
- Study data/information will only be used for the research purposes.

3.2.5 Common indications:

1. Proptosis.
2. Visual disturbance.
3. Evaluation of orbital or ocular mass lesion

Chapter Four

Results

Chapter Four

Results

The following tables and figures represented the data obtained from 30 patients who were examined for sagittal and coronal MRI for orbits, the optic nerve width and length was measured, patients age, gender, diabetes duration have also been examined. The data was analyzed using SPSS version 20 for significances of tests. Frequency tables mean and standard deviations were presented.

4.1 Optic nerve measurements:

Table 4.1 shows the duration of diabetes among diabetic patients and control group:

	Number	Minimum	Maximum	Mean	Standard Deviation (SD)
age Cases	30	34	85	59.5	15.345
age Control	20	30	85	57.5	15.913
Duration of diabetes	30	10	35	21.77	8.386

Table 4.2 shows distribution of gender among diabetic patients and control group:

	Case		Control	
	Frequency	Percentage	Frequency	Percentage
Male	15	50%	12	60%
Female	15	50%	8	40%
Total	30		20	

Table 4.3 shows types of diabetes:

	Frequency	Percentage
Type 1	20	66.7%
Type 2	10	33.3%
Total	30	

Table 4.4 shows mean of measurements for the right/left sagittal and right/left coronal of the optic nerve among diabetic patients:

		No	Min (cm)	Max (cm)	Mean (cm)	SD
Right	sagittal measurements	30	2.6	3.1	2.867	0.1269
	Coronal measurements	30	0.3	0.4	0.343	0.0504
Left	Sagittal measurements	30	2.6	3.1	2.85	0.1432
	Coronal measurements	30	0.3	0.4	0.343	0.0504

Table 4.5 shows mean of measurements for the right/left sagittal and coronal of the optic nerve among Control group:

		No	Min(cm)	Max(cm)	Mean(cm)	SD
Right	sagittal measurements	20	2.9	3.6	3.27	0.2296
	Coronal measurements	20	0.4	0.6	0.49	0.0852
Left	sagittal measurements	20	2.9	3.6	3.27	0.2296
	Coronal measurements	20	0.4	0.6	0.49	0.0852

Table 4.6 shows comparison of the right sagittal and right coronal measurements of the optic nerve between males and females:

		No	Mean(cm)	SD	P value	Comment
sagittal measurements	Male	27	3.052	0.2694	0.495	Insignificant
	Female	23	3	0.2611		
Coronal measurements	Male	27	0.404	0.098	0.896	Insignificant
	Female	23	0.4	0.1		

Table 4.7 shows comparison of the left sagittal and left coronal measurements of the optic nerve between males and females:

		No	Mean(cm)	SD	P value	Comment
sagittal measurements	Male	27	3.033	0.2909	0.674	Insignificant
	Female	23	3	0.2611		
Coronal measurements	Male	27	0.404	0.098	0.896	Insignificant
	Female	23	0.4	0.1		

Table 4.8 shows comparison of the right sagittal and right coronal of the optic nerve between diabetic patients and control:

		No	Mean(cm)	SD	P value	Comment
sagittal measurements	Case	30	2.867	0.1269	0.000	Significant
	Control	20	3.27	0.2296		
Coronal measurements	Case	30	0.343	0.0504	0.000	Significant
	Control	20	0.49	0.0852		

Table 4.9 shows comparison of the left sagittal and left coronal in optic nerve between diabetic patients and control group:

		No	Mean(cm)	SD	P value	Comment
sagittal measurements	Case	30	2.85	0.1432	0.000	Significant
	Control	20	3.27	0.2296		
Coronal measurements	Case	30	0.343	0.0504	0.000	Significant
	Control	20	0.49	0.0852		

Table 4.10 shows comparison of the right sagittal and right coronal of the optic nerve between types of diabetes:

		No	Mean(cm)	SD	P value	Comment
sagittal measurements	Type 1	20	2.885	0.1182	0.27	Insignificant
	Type 2	10	2.83	0.1418		
Coronal measurements	Type 1	20	0.35	0.0513	0.314	Insignificant
	Type 2	10	0.33	0.0483		

Table 4.11 shows comparison of the left sagittal and left coronal of the optic nerve between types of diabetes:

		No	Mean(cm)	SD	P value	Comment
Sagittal measurements	Type 1	20	2.86	0.1465	0.598	Insignificant
	Type 2	10	2.83	0.1418		
Coronal measurements	Type 1	20	0.35	0.0513	0.314	Insignificant
	Type 2	10	0.33	0.0483		

Table 4.12 shows association of the right sagittal and right coronal of the optic nerve with age and duration of disease:

	Pearson Correlation	P value	Comment
sagittal measurements and age	-0.411	0.003	Significant Negative
sagittal measurements and duration	-0.601	0.000	Significant Negative
Coronal measurements and age	-0.406	0.003	Significant Negative
Coronal measurements and duration	-0.391	0.032	Significant Negative

Table 4.13 shows association of the left sagittal and left coronal of the optic nerve with age and duration of disease:

	Pearson Correlation	P value	Comment
sagittal measurements and age	-0.405	0.004	Significant Negative
sagittal measurements and duration	-0.530	0.003	Significant Negative
Coronal measurements and age	-0.406	0.003	Significant Negative
Coronal measurements and duration	-0.391	0.032	Significant Negative

Chapter Five

Discussion, Conclusion and Recommendations

Chapter Five

Discussion, Conclusion, and Recommendations

5.1 Discussion:

The effect of diabetes on optic nerve and optic chiasm analyzed by MRI for orbits(30) diabetic patients Compared to 20 as control group) statistical significance was demonstrated regarding. Table 4.1 showed the number of cases and its distribution to30 diabetic patients and 20 as control group. Table 4.2 showed the distribution of gender in diabetic patients in to 15 male and 15 female. Table 4.3 showed types of diabetes type1and type2. Table 4.4 and table 4.5 showed the measurements for the right/left sagittal and right/left Coronal among diabetic patients and control group. The mean of the right sagittal measurements in diabetic patients was 2.867 and the SD deviation is 0.126 and the mean of the right coronal measurements in diabetic patients was 0.343 and the standard deviation was 0.0504. The left sagittal measurements was 2.85 SD deviation was 0.1432. The mean of the Coronal measurements was 0.343 SD 0.0504. The control group measurements mean for the right sagittal was 3.27 and SD deviation 0.2296. The right coronal was 0.49 and SD deviation 0.0852. The left sagittal was 3.27 and SD deviation 0.2296. The left coronal mean was 0.49 and SD deviation 0.0852.therefore the mean measurement of the optic nerve in diabetic patients was less than control group (2.867 to 3.27 in sagittal, 0.343 to 0.49 in coronal). Table 4.6 and table 4.7 showed the comparison of the right/left sagittal and coronal between males and females. The P-value of the sagittal measurements between the males and females was 0.4495 when the coronal measurements were 0.896. The measurements were insignificant in both genders which mean the gender has no effect on diabetes. Table 4.8 and table 4.9 showed a comparison of a right/left sagittal and coronal between diabetic patients and the control group when P-value in both diabetic patients

and control group was 0.000 which means there is a significant difference. Table 4.10 and 4.11 showed a comparison of the right/ left sagittal and coronal in optic nerve between types of diabetes. The P-value in the right sagittal measurements between type 1 and type 2 was 0.27 and the P-value of the right coronal measurements between type 1 and type 2 was 0.314. The P-value in the left sagittal measurements between type 1 and type 2 was 0.598 and the P-value of the left coronal measurements between type 1 and type 2 was 0.314. The study of both types showed an insignificant measurement in both types which means that optic nerve affected in both types. Table no 4.12 and table 4.13 showed the association of the right/left sagittal and coronal of the optic nerve with age and duration of disease. The Pearson correlation on both right and left sagittal and coronal was a significant negative which means that when the duration of diabetic increased the measurements of the optic nerve decreased.

5.2 The Conclusion:

There are significant correlation between Optic nerve diameter and patient who are Dioptric.

There is no affected or different between affected patient gender

The patient aged affiliated the O.N diameter so that increase patient age decrease O.N.

There is negative correlation bet duration of diabetic and optic nerve diameter so that increase duration degrees optic new diameter.

Diabetes affects the optic nerve. The study found that in a comparison between males and females in the measurement of the optic nerve, the results was insignificant which means the diabetes has no effect on gender. In a comparison between types of diabetic there were also insignificant results. In a comparison between diabetic patients and control group there was a significant different in measurements of the optic nerve. The patient age affect the optic nerve diameter in length and widths. The gender has no effect on the optic nerve diameter in diabetic patient. When the duration of diabetic increased the measurements of the optic nerve decreased.

5.3 The Recommendations:

1. D. M. must be controlled.
2. Follow up of D.M to avoid O.N affacted.
3. Large Sample Size to show manag corrlation.
4. Use other Imaging modalistes to assess .O.N so as us
5. All opthalonic drpartment must have MRI machine for assesse the relationship bet brain parts &optic nerve and optic chisma.

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Appendix

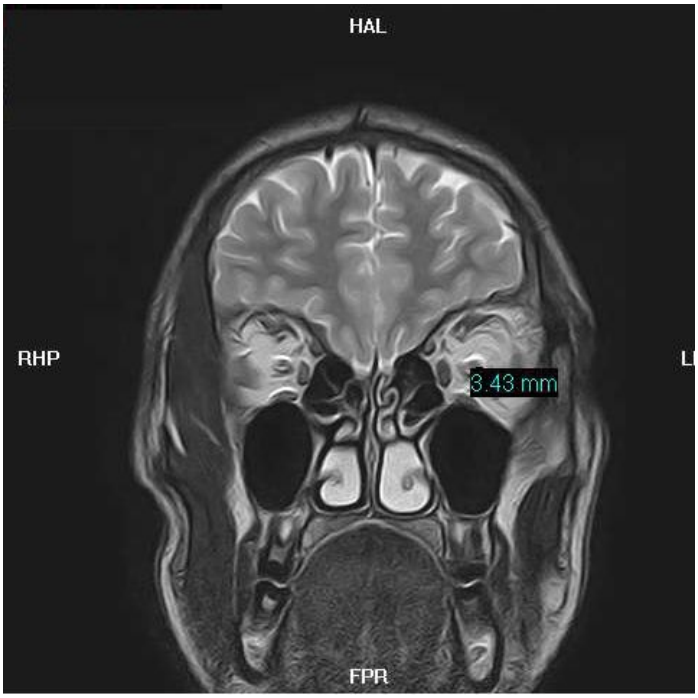
The Appendix:

Dar Alelaj Specialized Hospital

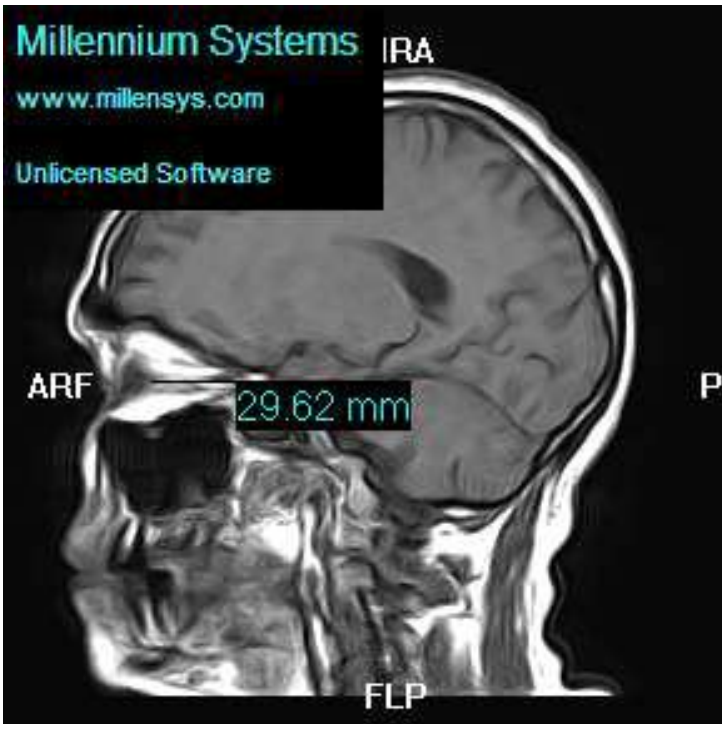
No.	Name	Gender	age	measurement		Type of diabetes	Duration of	Other finding
				Sagittal	coronal			
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								
26								
27								
28								
29								
30								

The Control Group Questioner

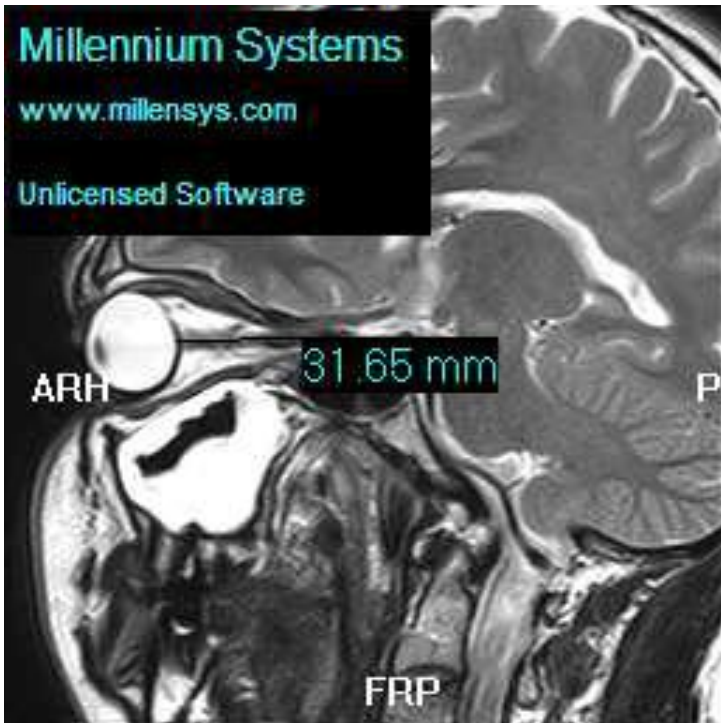
No.	Name	Age	Gender	Measurements	
				Coronal	Sagittal
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					



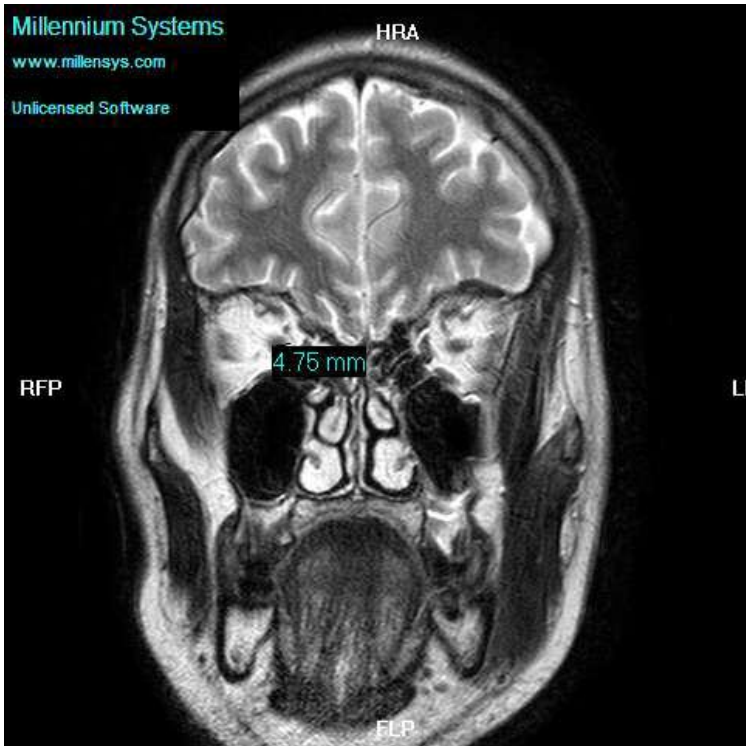
Case (1) left coronal: Male 35y



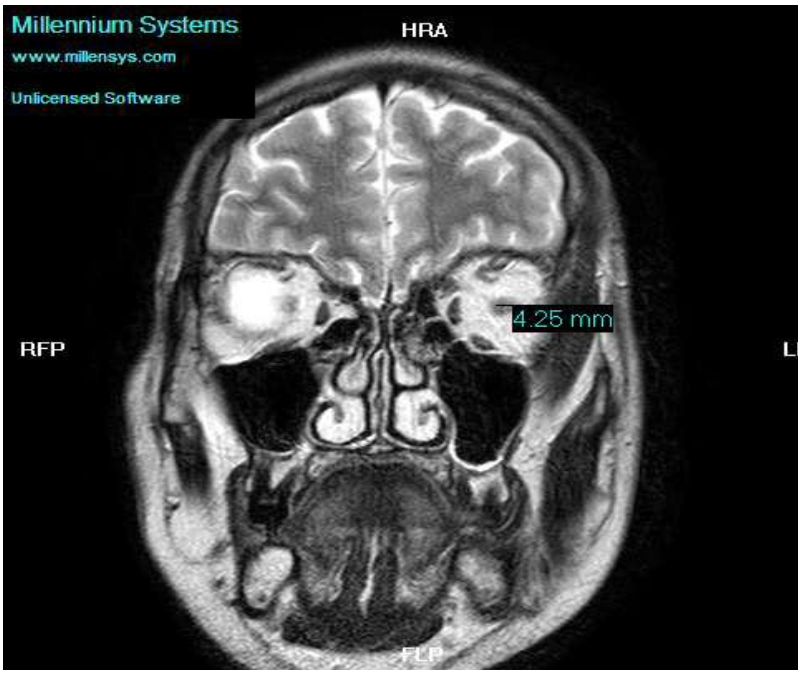
Case (2) right sagittal: Male 55y



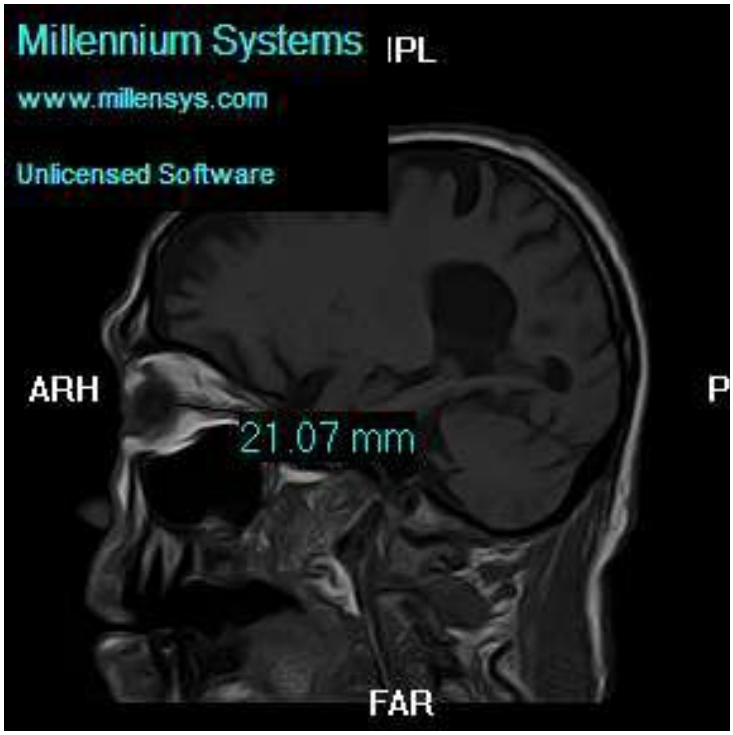
Case (3) left sagittal. Male 45Y



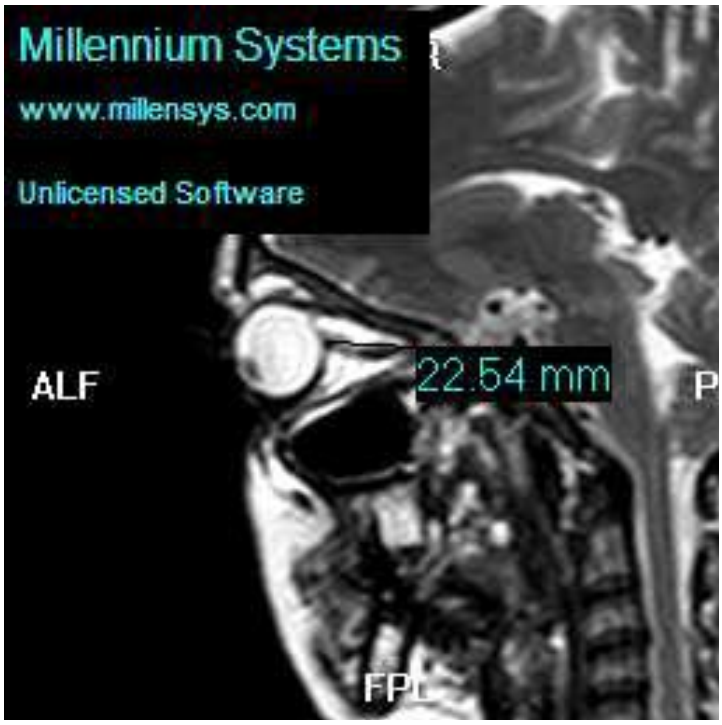
Case (4) right coronal F.40Y



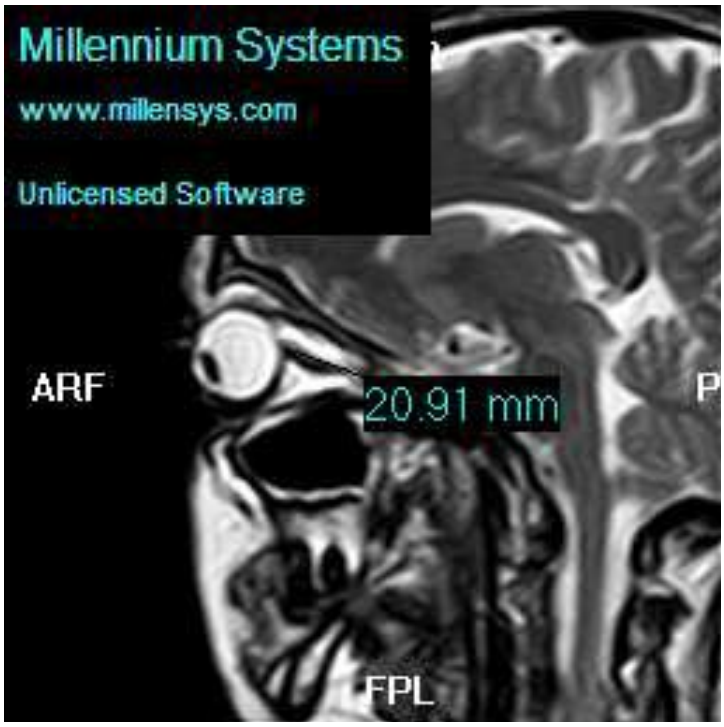
Case (5) lest coronal F 39 Y



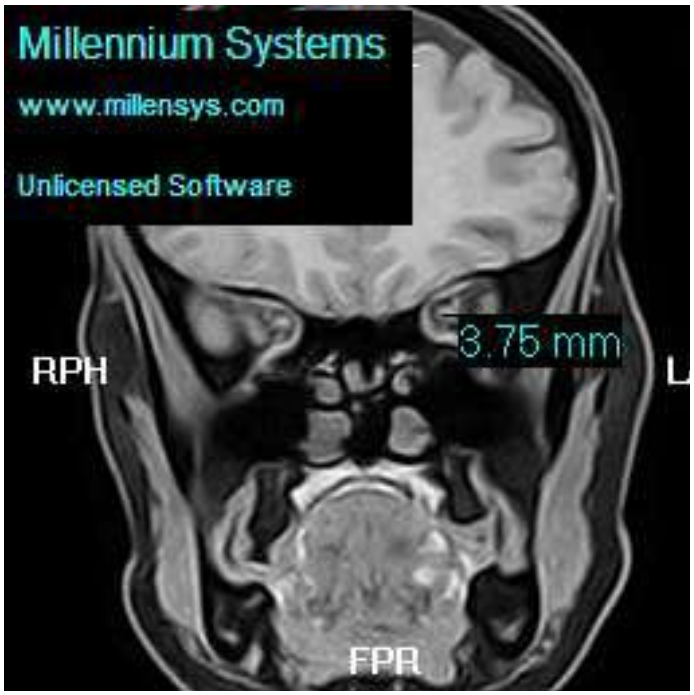
Case (6) right sagittal: M .60.Y



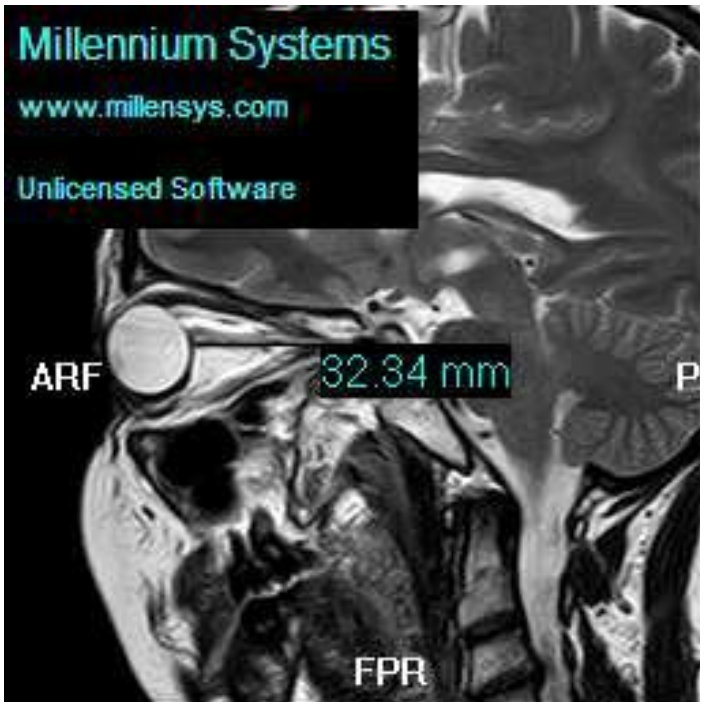
Case (7) left sagittal: F 52 Y



Case (8) right sagittal M 54 Y

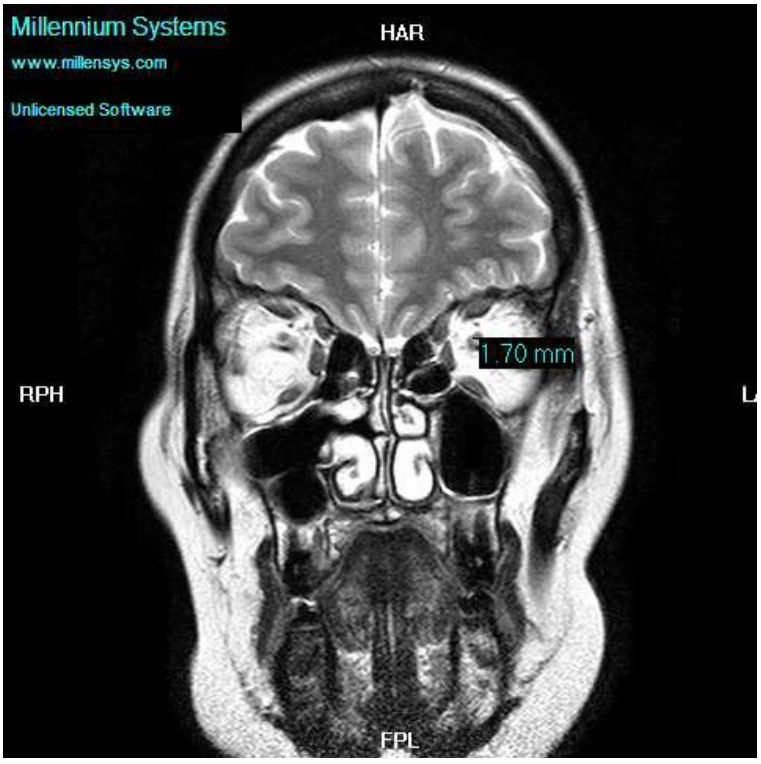


Case (9) left coronal M 35 Y

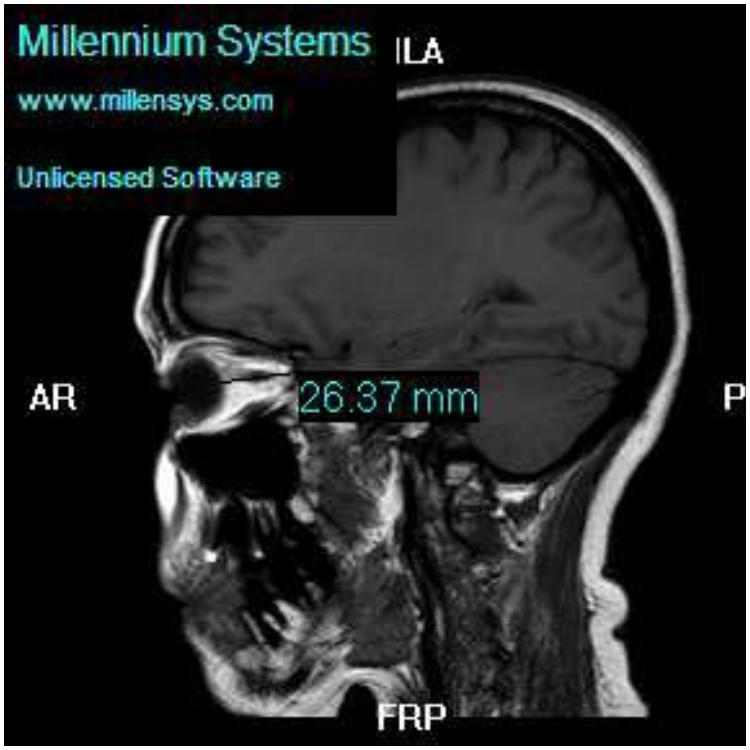


Case (10) left sagittal: F 37 Y

Case (11) right sagittal: M 38 Y



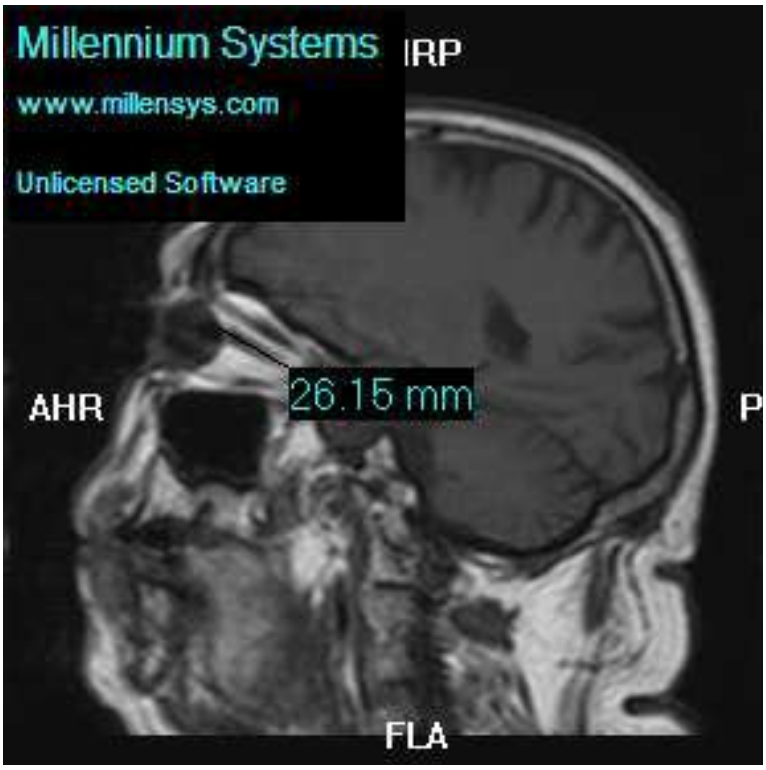
Case (12) left coronal : M 70 Y



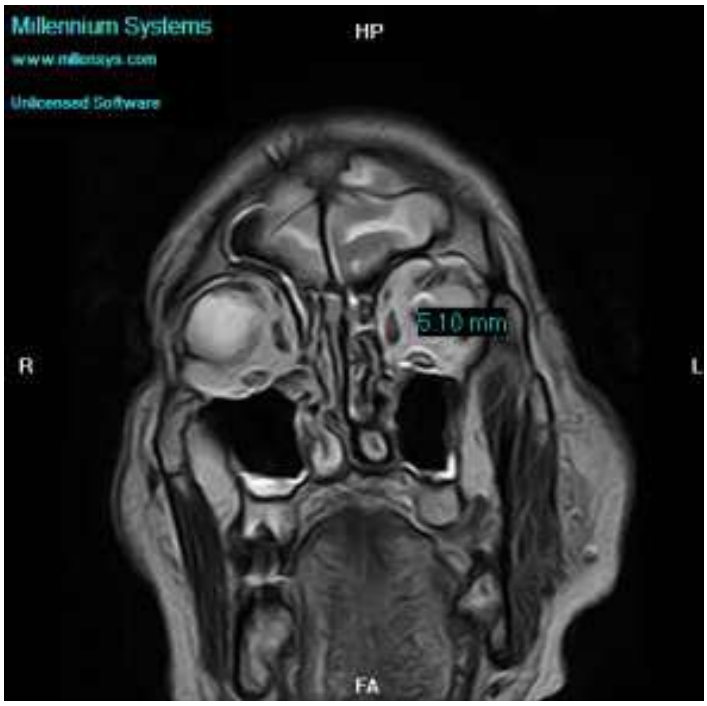
Case (13) left sagittal: M 62 Y

Case (14) right coronal: F 35 Y

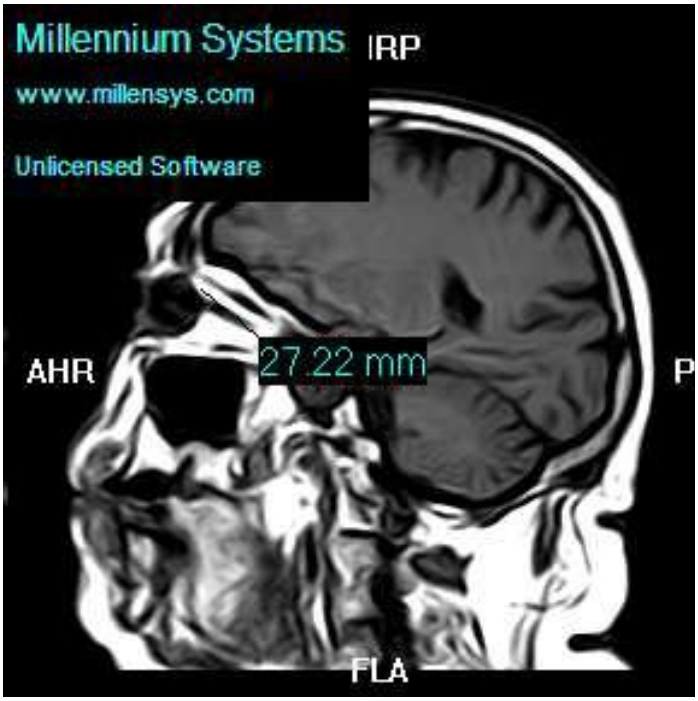
Case (15) left coronal: M 62 Y



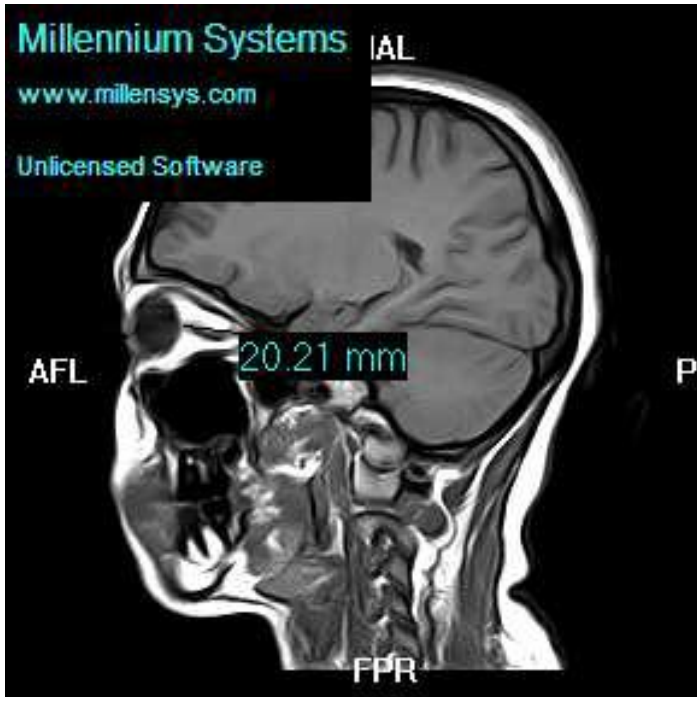
Case (16) left sagittal:F 47 Y



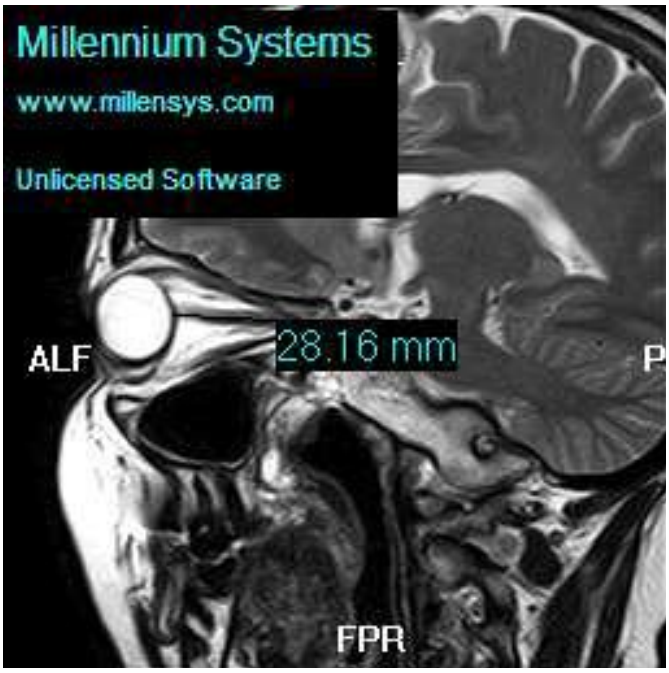
Case (17) left coronal: M 43 Y



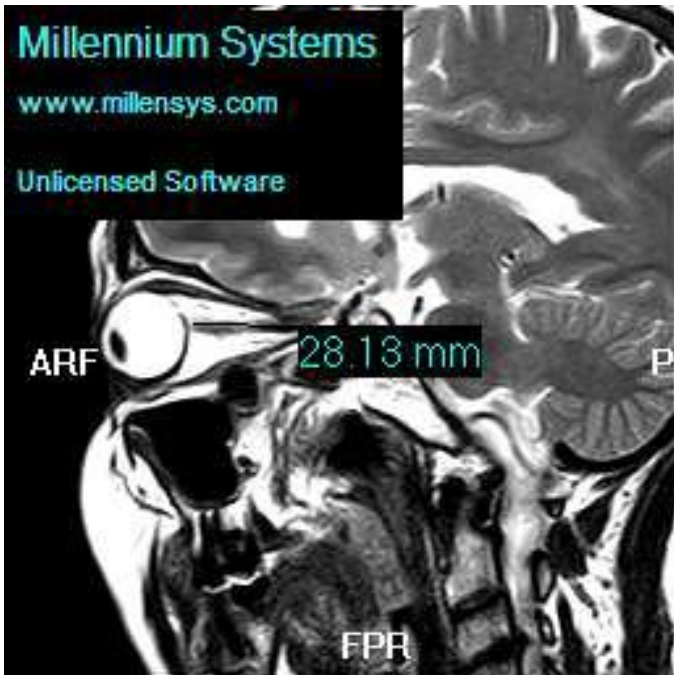
Case (18) right sagittal: M 48 Y



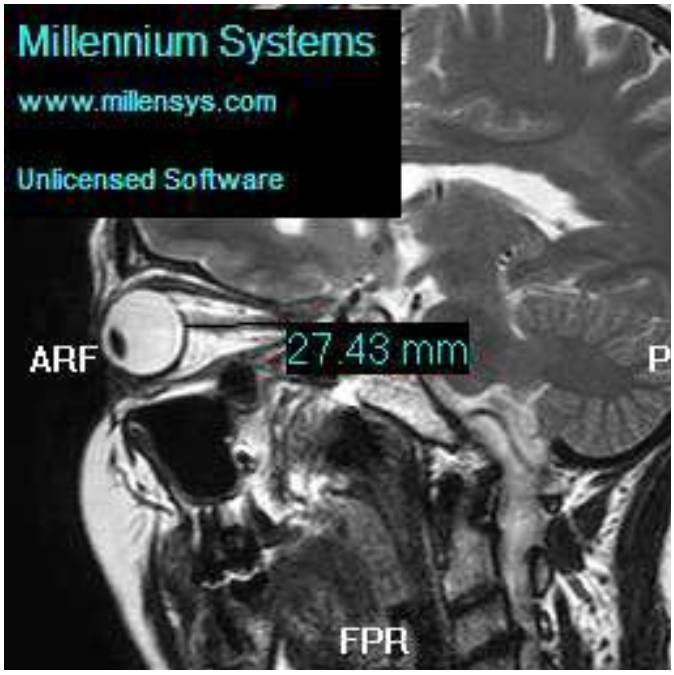
Case (19) right sagittal F 72 Y



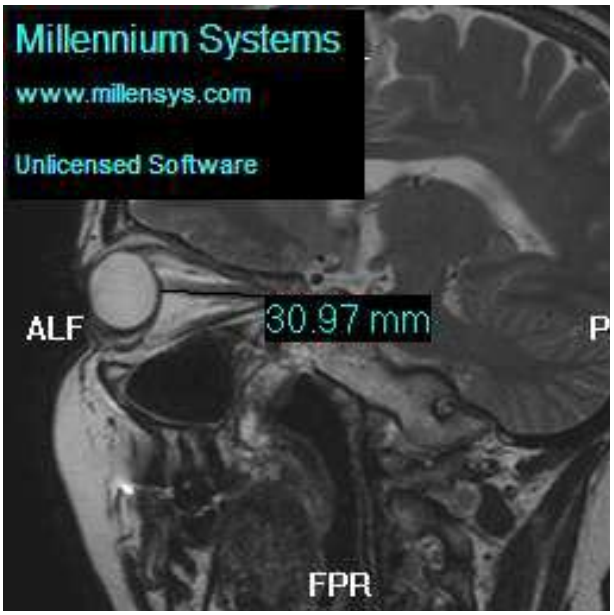
Case (20) left sagittal: F 67 Y



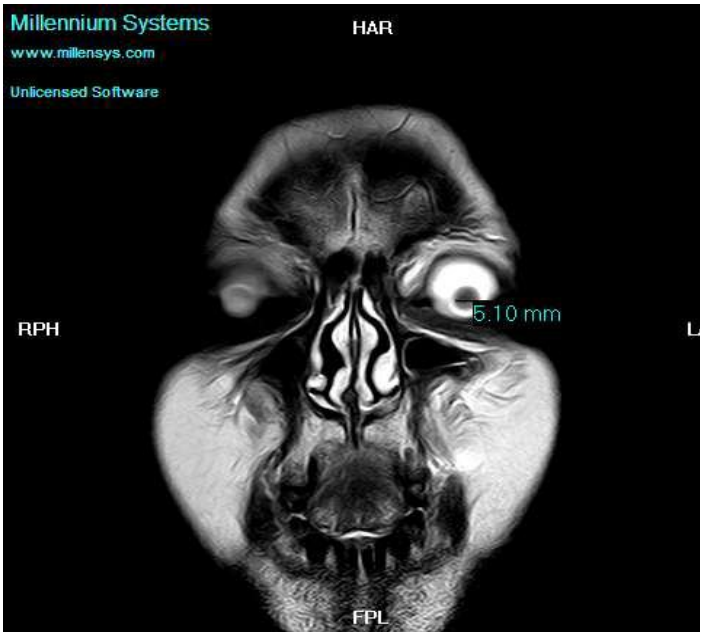
Case (21) right sagittal: M 64 Y



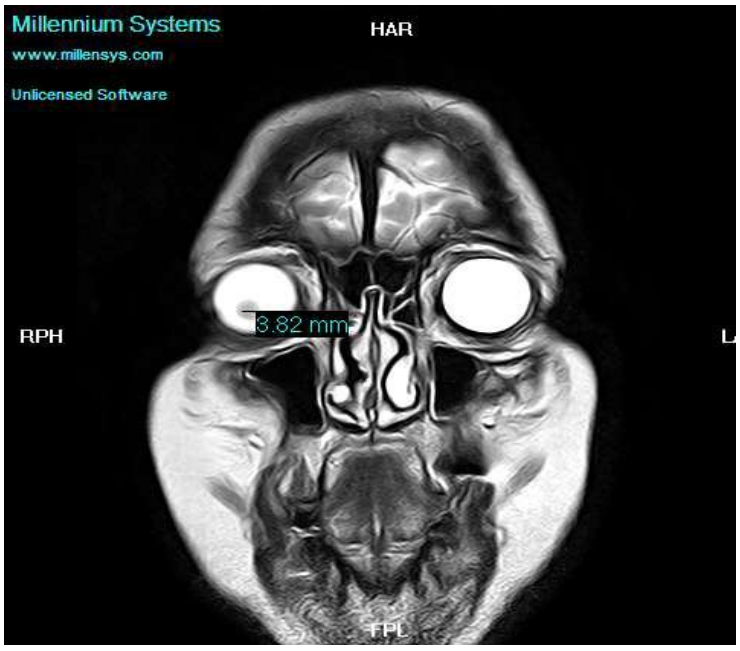
Case (22) right sagittal: M 50 Y



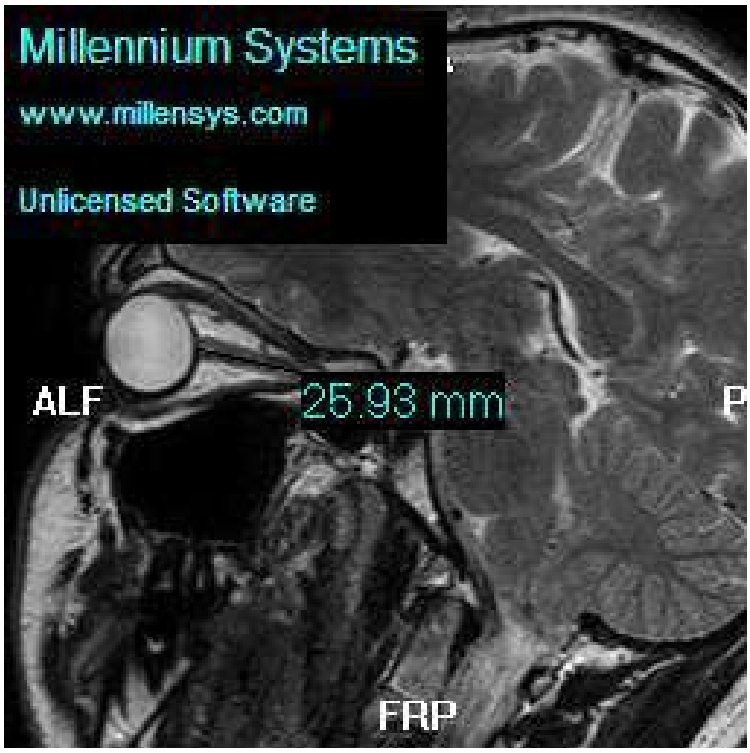
Case (23) left sagittal: F 44 Y



Case (24) right coronal: F 36 Y



Case (25) right coronal: F 47 Y



Case (26) left sagittal: M 73 Y

Case (27) right coronal: F 37 Y

Case (28) left sagittal: F 41 Y

case (29) right sagittal: F 59 Y

Case (30) left sagittal: F 44 Y