Sudan University of Science and Technology
College of Graduate Studies

Estimation of Normal Corpus Callosum among Adult using Magnetic Resonance Imaging

تقدير الجسم الثفني الطبيعي لدى البالغين باستخدام التصوير بالرنين المغناطيسي

A Research submitted for partial fulfillment for the Requirements of M.Sc. degree in Diagnostic Radiologic Technology

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الآيـة

قال تعالى :

بِسْمِ اللَّهِ الرَّحْمَٰنِ الرَّحِيم

(قُل لَّوْ كَانَ ٱلْبَحْرُ مِدَادًا لِّكَلِمَت رَبِّى لَنَفِدَ ٱلْبَحْرُ قَبْلَ أَن تَنفَدَ كَلِمَتُ رَبِّى وَلَوْ جِئنا بِمِثْلِهِ مَدَدًا)

صدق الله العظيم

سورة الكهف(الآية 109)

Dedication

This thesis is proudly dedicated to ……

All my beloved family

My mother "zainab"

My brothers specially "Mohammed"

My sisters and my best friend "Nehad"

Thanks for your endless love, sacrifices, prayers, supports and advices

Acknowledgments

First and foremost, praises and thanks to Allah, the Almighty, I would like to thank my supervisor **Dr. Afraa Siddig** Hassan Omer for her support, outstanding guidance.

Special thanks to **Dr. Ahmed Mostafa Abukonna** for his help and everyone participated in this work by any way encourages either advising or appreciating our research.

Abstract

The aim of this study was to measurement of corpus callosum (CC) concerning gender and age related variation for Sudanese population using magnetic resonance imaging (MRI).

This study was done on the time period from September to December 2021 in almoalem medical city and Ahmed gasim hospital within MRI machine scan department in Khartoum.

MRI scan done for 51males and 49 females, ranging in age from 25 to 80 years, were reviewed. Only MRI studies without pathological finding were included in the study analysis.

The data was collected by using data collection sheet include variables(gender, age, length of cc, thickness of rostrum, thickness of genu, thickness of body and thickness of splenium) and analyzed by statistical package for social science and correlation persons coefficient(SPSS).

The study results were presented the length of corpus callosum 75.93mm and the thickness was divided to rostrum 6.95mm, genu 10.60mm, body 6.13mm and splenium 11.28mm. The study found there was statistically significant correlation between age and [genu, splenium, body and rostrum thickness] (p-values < 0.05), statistically insignificant correlation between age and length CC (p-values > 0.05) and between gender and [length CC, genu, splenium, body and rostrum thickness] (p-values > 0.05). There was statistically significant difference between age groups in [length CC, genu, splenium, body and rostrum thickness] (sig. < 0.05). Also the study found in frequency of males 51 and females 49 was no significant difference in corpus callosum. The study concluded that the magnetic resonance imaging was the best modalities for measurement of corpus callosum.

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المستخلص

كان الهدف من هذه الدراسة هو قياس الجسم الثفني فيما يتعلق بالتباين الجنساني والعمري للسكان السودانيين باستخدام التصوير بالرنين المغناطيسي.

وقد بدأت هذه الدراسة في الفترة الزمنية الممتدة من سبتمر الي ديسمبر 2021 في مدنية المعلم الطبية ومستشفى أحمد قاسم داخل قسم التصوير بالرنين المغناطيسي في الخرطوم.

تم استعراض التصوير بالرنين المغناطيسي من 51 الذكور و49 الإناث، الذين تتراوح أعمارهم بين 25 إلي 80 عاما. ولم يشمل التحليل سوى دراسات التصوير بالرنين المغناطيسي دون وجود أي نتائج مرضية.

وتشمل البيانات التي تم جمعها باستخدام ورقة جمع البيانات المتغيرات (نوع الجنس، والعمر، وطول الجسم الثفني، وسمك المنصة، وسمك الجينو، وسمك الجسم، وسمك الطحال) وتم تحليلها بواسطة حزمة إحصائية للعلوم لاجتماعية ومعامل ارتباط بيرسون (SPSS).

تم عرض نتائج الدراسة بطول الجسم الثفني 75.93 مم وقسم السمك على المنبر 6.95 مم والجنو 10.60 مم والجسم 6.13 مم والطحال 11.28 مم. وجدت الدراسة أن هناك علاقة ذات دلالة إحصائية بين العمر و [الجين ، الطحال ، الجسم وسمك المنصة] (قيم $p < 0.05$) ، علاقة غير ذات دلالة إحصائية بين العمر وطول الجسم الثفني (قيم $p > 0.05$) وبين الجنس و [طول الجسم الثفني والجيني والطحال والجسم وسمك المنبر] (قيم $p > 0.05$). كانت هناك فروق ذات دلالة إحصائية بين الفئات العمرية في [طول الجسم الثفني ، الجنو ، الطحال ، سمك الجسم والمنبر] (sig. <0.05). كما وجدت الدراسة أن معدل تكرار الذكور 51 والإناث 49 لا يوجد فرق معنوي في الجسم الثفني. وخلصت الدراسة إلى أن التصوير بالرنين المغناطيسي كان أفضل الطرق لقياس الجسم الثفني.

وخلصت الدراسة إلى أن التصوير بالرنين المغناطيسي كان أفضل الطرق لقياس الجسم الثفني.

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List of abbreviations

CC	Corpus Callosum
ACC	Agenesis of the Corpus Callosum
MRI	Magnetic Resonance Imaging
P	Population
SPSS	statistical Package for the Social Sciences
MM	Millimeter
P. V	Population value
APD	Anteroposterior Diameter of the Corpus Callosum
RT	Rostrum Thickness
GT	Genu Thickness
BT	body Thickness
ST	Splenium Thickness

Chapter one

Introduction

Chapter one

Introduction

1.1Introduction:

The corpus callosum is the primary commissural region of the brain consisting of white matter tracts that connect the left and right cerebral hemispheres. It is composed of approximately 200 million heavily myelinated nerve fibers that from homotopic or heterotopic projections to contralateral neurons in the same anatomical layer. During infancy, the corpus callosum expands rapidly due to an increase in the number of axons, axon diameter, and myelin. Although the development of the corpus callosum is complete by age four, growth continues until the third decade of life at a much slower rate. Anatomically from anterior to posterior, the corpus callosum is composed of four parts based on previous histological finding: the rostrum, genu, body and splenium, each responsible for connecting distinct areas of the cortex. The isthmus refers to the narrow region between the body and splenium in the posterior aspect of the corpus callosum. Fibers of the genu cross over and give rise to the forceps minor, a connection between regions of the frontal cortices. The fibers of the splenium move posteriorly and contribute to the forceps major, providing a connection between the occipital lobes. The body fibers form the corona radiate as well as other large white matter pathways as they move transversely through the cerebral cortex. Finally, the orbital regions of the frontal lobes connect via the rostral fibers. (Goldstein 2021)

The variability of the adult CC may vary with gender and age. There are, however, little data on the morphology of the CC in the Sudanese population. The purpose of this study was to investigate the relationship between morphometric CC measurements, age, and gender and establish CC reference values in Sudanese adults using MRI.

1.2 problem of the study:

Agenesis of the corpus callosum (**ACC**)) is one of several disorders of the corpus callosum, the structure that connects the two hemispheres (left and right) of the brain. In ACC the corpus callosum is partially or completely absent. It is caused by a disruption of brain cell migration during fetal development. The normal corpus callosum well demonstrated by magnetic resonance imaging (MRI) there for the measure should be known in order to void miss diagnosis.

1.3 Objective of the study:

1.3. 1General objectives.

Measurement of corpus callosum in Adult Using MRI.

1.3.2 Specific objectives:

- To measure the thick and length of the corpus callosum (rostrum, genu, body and splenium).

- To correlate the measurement with age and gender.

1.4 Thesis layout

- Chapter One: Introduction
- Chapter Two: Theoretical background and previous studies
- Chapter three: Materials and methods
- Chapter four: Results
- Chapter five: discussion, conclusion and recommendation
- References

Chapter two

Theoretical background and previous studies

Chapter two

Theoretical background and previous studies

2.1 Theoretical background:

2.1.1 Anatomy

The corpus callosum is the largest of multiple commissural connections between the two sides of the diencephalon and telencephalon and carries most of the axonal connections from the neocortex to the opposite neocortex. In an adult human, it is approximately 10 cm long, 1 cm wide, and contains approximately 200 million axonal fibers. Standard anatomic divisions are the rostrum, genu, body, isthmus, and splenium. (Holloway, 2016)

The majority of callosal fibers originate from the pyramidal cells of the cerebral cortex. Most of the callosal fibers are thin, nonmyelinated, and slow conducting. Cortical association regions, in particular the prefrontal areas, contribute a high density of thin transcallosal fibers. Fast-conducting large fibers are typical of the interhemispheric connection between the primary and secondary sensory and motor cortices. (Holloway, 2016)

The majority of the callosal projections are homotopic, i.e., they connect homologous cortical areas of both cerebral hemispheres. The anterior third connects the *prefrontal* cortices; its size has a significant direct correlation with the forebrain volume. The mid-third contains connections between the motor, somatosensory, and auditory cortices. The posterior third contains visual fibers from the occipital cortex and projections from associative parietal and temporal brain areas. The isthmus contains connecting fibers between superior temporal and inferior parietal areas. (Holloway, 2016)

The corpus callosum is a large white matter tract that connects the two hemispheres of the brain. It is an incredibly important structural and functional part of the brain. It allows us to perceive depth and enables the two sides of our brain to communicate. (Ahmadvand et al., 2017)

The corpus callosum gets its name from the Latin language ("tough body"). It is the largest white matter structure in the brain both in terms of size (700 square millimeters for the midsagittal cross-section) and number of axonal projections (200 million) between the two hemispheres. (Ahmadvand et al., 2017)

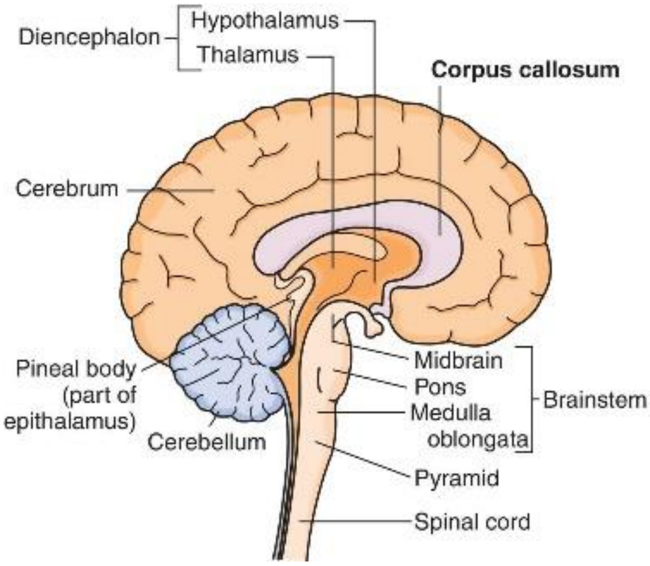

Figure (2.1): corpus callosum

(https://en.wikipedia.org/wiki/Corpus_callosum)

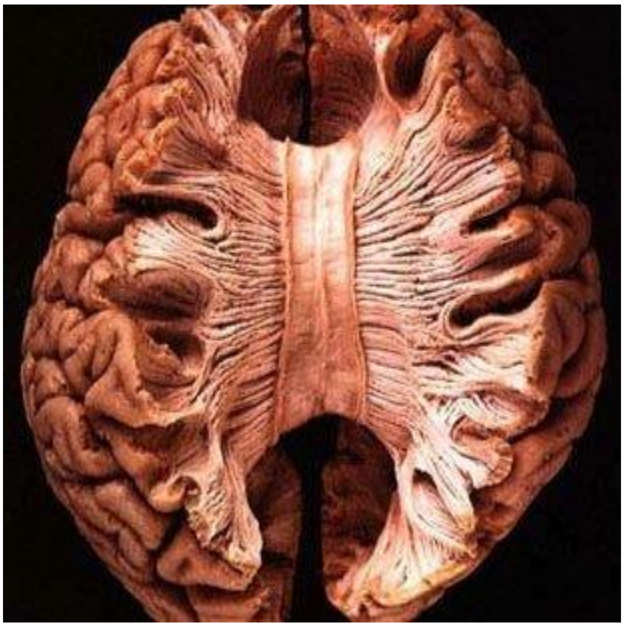

Fig (2-2): Corpus callosum from above. (Anterior portion is at the top of the image) (https://en.wikipedia.org/wiki/Corpus_callosum)

2.1.2 Structure of the corpus callosum:

The corpus callosum is divided into four parts: rostrum, genu, body/trunk and splenium

- The rostrum is continuous with the lamina terminalis and connects the orbital surfaces of the frontal lobes.
- The genu is the bend of the anterior corpus callosum and the forceps minor is a tract that projects fibres from the genu to connect the medial and lateral surfaces of the frontal lobes.
- The body forms the long central section and its fibres pass through the corona radiata to reach the surface of the hemispheres.

Splenium tapers away at the posterior section, with the forceps major projecting fibres from the splenium to connect the two occipital lobes.

White matter fibres projecting from the body and fibres from the splenium not included in the forceps major are known as the tapetum, and run along the entire lateral occipital and temporal horns of the lateral_ventricle. Broadly speaking there are two types of connections: homotopic and heterotopic.

Homotopic connections link similar regions from the left and right sides of the brain, while heterotopic connections connect dissimilar areas of the left and right sides of the brain. (Ahmadvand et al., 2017)

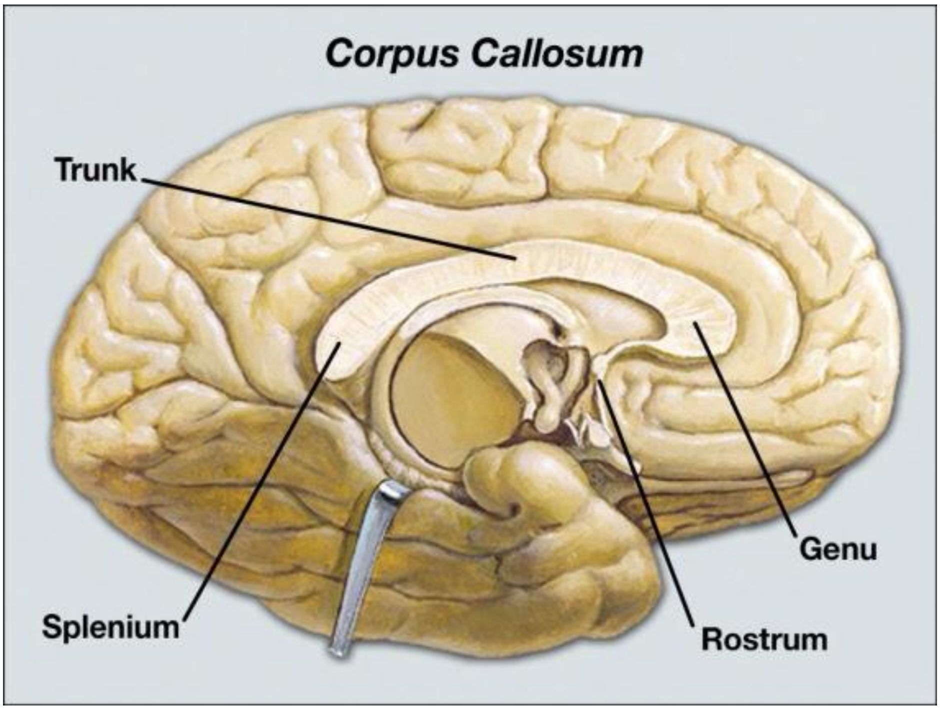

Figure (2.3):There are four main parts to the corpus callosum.

https:// anatomy info. Com/corpus callosum (Boiagina and Vovk, 2019)

2.1.3 Relations:

Immediately above the body of the corpus callosum, lies the interhemispheric fissure in which runs the falx cerebri and branches of the anterior cerebral vessels. The superior surface of the corpus callosum is covered by a thin layer of grey matter known as the indusium griseum. (Gajera Jay 2022)

On either side, the body is separated from the cingulate gyrus by the callosal sulcus. (Gajera Jay 2022)

Attached to the concave undersurface of the corpus callosum is the thin vertical septum pellucidum anteriorly, and the fornix and its commissure posteriorly. (Gajera Jay 2022)

2.1.4 Sexual dimorphism:

The corpus callosum and its relation to sex has been a subject of debate in the scientific and lay communities for over a century. Initial research in the 5 early20th century claimed the corpus to be different in size between men and women. That research was in turn questioned, and ultimately gave way to more advanced imaging techniques that appeared to refute earlier correlations.

However, advanced analytical techniques of computational neuro anatomy developed in the 1990s showed that sex differences were clear but confined to certain parts of the corpus callosum, and that they correlated with cognitive performance in certain tests. One recent study using magnetic resonance imaging (MRI) found that the midsagittal corpus callosum cross sectional areas, on average, proportionately larger in females. (Shiino, et al., 2017)

2.1.5 Blood Supply and Lymphatics:

The internal carotid artery network provides arterial blood supply to a majority of the corpus callosum, specifically via the pericallosal artery (a branch of the anterior cerebral artery). The splenium is the exception as it receives vascular input from the vertebrobasilar system. The terminal and choroidal branches of the posterior cerebral artery supply the splenium with arterial blood. Venous drainage occurs via the callosal and callosal cingular veins and, ultimately, the internal cerebral veins. (Goldstein 2021)

2.1.6 Venous drainage:

Various small veins draining the central parts of the corpus callosum drain into the internal cerebral veins, in turn draining into the straight sinus. Tributaries of the internal cerebral veins draining the corpus callosum include:

- callosal veins
- callosocingulate veins
- subependymal veins
- septal veins

In addition, pericallosal veins follow their arterial counterpart over the superficial surface os the corpus callosum:

- posterior pericallosal veins (splenial veins) drain the splenium and drain directly into the straight sinus or great cerebral vein (of Galen)

Anterior pericallosal veins drain the genu and rostrum and drain into the anterior cerebral vein (Gajera Jay 2022)

2.2 Physiology of the corpus callosum:

The primary function of the corpus callosum is to integrate and transfer information from both cerebral hemispheres to process sensory, motor, and high-level cognitive signals. There have been significant advances made in learning more about the corpus callosum's role by studying callosotomy patients with partial or total hemispheric disconnection. Based on these observations, the corpus callosum seems to have a topographical organization, involved in the transfer of visual, auditory, and somatosensory information in posterior regions, and higher cognition is processing anteriorly. There is evidence for the idea that the anterior callosal fibers transfer motor information between the frontal lobes, and the posterior fibers are involved in the processing of somatosensory (posterior midbody), auditory (isthmus) and visual (splenium) cues by connecting the parietal, temporal, and occipital lobes. As the brain matures and white matter develops, the corpus callosum seems to play a crucial role in refining motor movements and cognitive functions. Additional studies have shown that the corpus callosum has an inhibitory effect that normally prevents alien-hand syndrome and uncoordinated hand-motor behavior. (Goldstein 2021)

2.2.1 Physiologic Variants:

Physiologic variants of the corpus callosum include agenesis or hypoplasia. Agenesis of the corpus callosum is an uncommon brain malformation that either leads to a partial or total absence of the corpus callosum. Though rare, it is one of the more frequently occurring congenital malformations, affecting three to seven people per 1000 births. A diagnosis can be made using prenatal ultrasound and can be concurrent with malformations in midline structures like cavum septum pellicidum, as well as cortical and posterior fossa abnormalities. In part, it is the result of multiple developmental abnormalities, affecting steps as early as midline telencephalic patterning to later neuronal differentiation and axonal guidance. The cause is unknown but appears to be sporadic and possibly non-genetic. Despite the corpus callosum's crucial role in normal cognition, patients with isolated agenesis of the corpus callosum typically have good prognoses. Common deficits observed in this population include difficulty with problem-solving and socializing, often placing patients on the autism spectrum. These deficits, known as "disconnection syndrome," are different from those observed in commissurotomy patients, who most notably have impaired bimanual coordinated motor activity. Currently, 55% to 70% of agenesis of the corpus callosum cases are not identified based on clinical features. Hypoplasia is most benign when the rostrum is absent and often is not clinically significant. Therefore, it is commonly an incidental finding in a magnetic resonance imaging (MRI) scan obtained for other clinical reasons. (Goldstein 2021)

2.2.2 Surgical Considerations:

A corpus callosotomy is a surgical procedure for patients with refractory disorders despite maximum medical management. Also, it is the preferred surgical procedure for patients with refractory seizure disorder with drop attacks. Though controversial, some advocate for the surgical resection of the corpus callosum to treat low-grade gliomas as the migration patterns of these tumors typically involve the invasion of white matter tracts. (Goldstein 2021)

2.2.3 Clinical Significance:

The most common pathology associated with the corpus callosum is multiple sclerosis, resulting in demyelinating lesions in the corpus callosum and pericallosal region. Corpus callosum congenital anomalies are often associated with other brain defects, so evidence of an abnormality in corpus callosum development should prompt a workup for other potentially serious defects. In addition to the physiologic variants, corpus callosum lipomas are considered to be congenital malformations of the primitive meninges. Corpus callosum lipomas classify as either curvilinear, which are usually located posteriorly and are asymptomatic, and tubulonodular, which are found anteriorly and associated with severe frontal abnormalities. Ischemia of the corpus callosum is uncommon due to vascular inputs from three main arteries:

the anterior communicating, anterior pericallosal, and posterior cerebral arteries. (Goldstein 2021).

2.3 imaging of the corpus callosum:

2.3.1 CT/MRI of the corpus callosum:

The usual morphological MRI sequences, a sagittal *T*1 or *T*2 (fluid-attenuated inversion recovery (FLAIR)) weighted plane, as well as DTI reformatting images for an optimal study of the CC, were implemented. (Fitsiori et al., 2011). MRI is the modality of choice for the study of the CC. As a densely packed white matter structure, the CC is visualized with a high signal in *T*1 weighted imaging (WI) and a low signal in *T*2 images. Sagittal plane images provide an overview of the structural integrity and extent of development of the CC, whereas in coronal images we can better evaluate its relationship to the cerebral hemispheres. (Fitsiori et al., 2011).

Complete assessment of CC pathologies is facilitated by the acquisition of the following sequences: *T*1 WI, fast spin-echo (FSE) *T*2 WI, as well as FLAIR sequences and volume acquisition sequences with high resolution. New techniques such as DTI have further expanded our capability to visualize the organization and orientation of the axonal pathways of the CC with tractography and quantitatively with the use of anisotropic indices of diffusion such as fraction anisotropy (FA) maps, permitting a better comprehension and analysis of the CC microstructure. (Fitsiori et al., 2011).

The use of susceptibility-sensitive sequences (susceptibility-weighting imaging (SWI)) plays an important role in the assessment of traumatic injury and other pathologies of the brain resulting in the deposition of blood products or calcium, including pathologies affecting the CC. Vascular (three-dimensional (3D) time-of-g0light (TOF)) sequences, on the other hand, are essential in cases of ischemic or hemorrhagic lesions. (Fitsiori et al., 2011).

Images after contrast media enhancement are not necessary for the study of malformations or traumatic pathologies of the CC. (Fitsiori et al., 2011).

If a viral infection is suspected, the MRI study, including perfusion sequences, should be repeated within 48–72 h after the initial study in order to confirm the diagnosis. (Fitsiori et al., 2011).

CT imaging is important for the diagnosis of CC lipomas and other pathologies with calcium deposition and can also be useful for the diagnosis of tumor, hemorrhage or infarction; CT angiography is essential for the diagnosis of aneurysms responsible for hematomas, more commonly situated in the anterior part of the CC. (Fitsiori et al., 2011).

2.4 Previous studies:

Study (1): Gender- and age-related differences in the morphology of the corpus callosum (J Suganthy et al. Clin Anat. 2003 Sep).

The purpose of this study was to measure the size of the corpus callosum in normal adult Indian males and females, and to identify gender- and age-related differences. The size of the corpus callosum on midsagittal section was measured in 100 (50 males, 50 females) normal adult Indians using magnetic resonance imaging. The length of the corpus callosum, the width of the genu, trunk, and splenium, the area of the splenium, and the total area of the corpus callosum were measured. The length of the brain also was measured. Means were compared for significant difference by gender using the Student's unpaired t-test and by age using ANOVA followed by Duncan's multiple range test. Gender was estimated by discriminant function analysis and age was estimated by regression analysis from significant parameters. The corpus callosum was longer in males and the discriminant score to differentiate gender was determined with an accuracy of 66%. The length of the corpus callosum increased with age and regression equations for predicting age was derived from the length of the corpus callosum. The width of the trunk and genu decreased with age in males but not in females. (Suganthy et al., 2003)

Study (2): Measurement of the Corpus Callosum Using Magnetic Resonance Imaging in the North of Iran :(Mohammadi, et al., 2011)

This study was done to measure the size of CC and to identify its gender- and age-related differences in the North of Iran. Patients and methods: The size of CC on midsagittal section was measured in 100 (45 males, 55 females) normal subjects using magnetic resonance imaging (MRI) admitted to the Kowsar MRI center in Gorgan-Northern Iran. Longitudinal and vertical dimensions of the CC, longitudinal and vertical lengths of the brain and the length of genu and splenium were measured. Data were analyzed by student's unpaired00 t test, ANOVA and regression analysis. Results: The anteroposterior length and vertical dimension of the CC, the length of genu and splenium were larger in males than in females, but these differences were not significant. The anteroposterior and vertical lengths of the brain were significantly larger in males than in females ($P < 0.05$). The length of CC increased with age and regression equations for predicting age were derived from the length of the CC. There was also a positive significant correlation between the anteroposterior length of the CC and the length of the brain and vertical dimension of the CC. Conclusions: This study showed that various CC parameters vary with the values documented in the Caucasian, Indian and Japanese population. (Mohammadi, Zhand, Mortazavi Moghadam and Golalipour, 2011)

Study (3): Measurement of corpus callosum in Sudanese population used sagittal magnetic images .by (Tagreed, 2017)

This Study aimed to measurement of corpus callosum in Sudanese population used sagittal magnetic resonance images.

The patient population consist of normal 50 males and 50 females.

The study was carried out in the (Sudan -Khartoum state) in radiology department of modern medical center and royal care international hospital from January 2016 to January 2017. The problem of the study was lacked to index value of normal corpus callosum in Sudanese population in order to avoid miss diagnosis. The data were collected and descriptive statistic used statistic package (Spss). The study results were presented the length of corpus callosum 75.75 and the thickness was divided to gnu 17.54, body 6.89 and splenium16.76. Also the study found in frequency of 50males and 50 females was no deferent in corpus callosum. The study found little difference in the size of the corpus callosum with age above 70 years old in both sexes. The study concluded that the magnetic resonance image was the beast modalities for measurement of corpus callosum .And the study concluded no significant difference in corpus callosum between both genders measurement in corpus callosum index. (Tagreed, 2017)

Study (4) Statistical shape analysis of differences in the shape of the corpus callosum between genders by Senem Turan Ozdemir et al. Anat Rec (Hoboken). 2007 Jul.

The aim of this study was to identify shape differences of the corpus callosum between genders. Landmark coordinate data were collected from two-dimensional magnetic resonance imaging scans of 93 homogeneously aged patients, 45 men and 48 women. These data were analyzed using Euclidean distance matrix analysis and thin plate spline analysis. The general shape variability of the corpus callosum of men was greater than that of women (men, 0.134; women, 0.097). We found no significant difference between sexes in the general shape of the corpus callosum, but we did find significant differences in the distances between some landmarks. Deformation of the corpus callosum between men to women was mainly detected in the posterior of the corpus callosum. These results serve as a reference for future studies on shape alterations of the corpus callosum associated with certain conditions. (Ozdemir et al., 2007)

Study (5) Characterization of the Corpus Callosum Morphology in Healthy Sudanese Adults using MRI (Alnour Badawi et al., 2020)

The aim of this study was to characterize the morphological differences of the corpus callosum (CC) concerning gender- and age-related variations, and establish reference values of the CC measurements for Sudanese participants using magnetic resonance imaging (MRI).

Methods and Results: MRI scans from 196 males and 189 females, ranging in age from 18 to 84, were reviewed. Only MRI studies without pathological findings were included in the analysis. The following measurements were done: the longitudinal dimensions of the brain, CC, the genu of CC, the splenium of CC, as well as craniocaudal height of the body of CC. Callosal longitudinal dimensions were measured using the Witelson division method. The longitudinal dimension of the genu was found to be larger in females (11.12±1.54 mm) than in males (10.73±1.75 mm) ($P=0.021$). The longitudinal dimension of the brain was greater in males (161.6±7.2 mm) than in females (159.3±7.6 mm) ($P=0.002$). There was a weak statistically significant direct correlation between age and CC ratio ($r=0.271$, $P<0.05$). Conclusion: The results revealed that only the genu length showed sexual dimorphism and was larger in females than in males. This study showed variabilities regarding the CC dimensions in Sudanese participants compared to the Caucasian, Indian, and Japanese population.

(Alnour Badawi et al., 2020)

Study (6) Measurement of Corpus Callosum Size Using MRI In Nepalese Population (Gnawali et al., 2021)

The aim of this study was to the dimensions of corpus callosum can be studied. In this cross-sectional quantitative study 80 cases of normal MRI head were selected for study over two months. T1 weighted sagittal spin-echo images with slice thickness of 6 mm, planned from an axial and coronal image were used for measuring length and thickness of corpus callosum. Obtained data were analyzed using SPSS ver.20 software and shown in frequency, percentages and bar diagram. The mean Corpus callosum (CC) length was 68.06 mm in the study population (n=80). The mean thickness of Genu, Body and Splenium were 9.15, 5.2 and 9.08 mm respectively and average thickness was 7.81 mm. statistically significant differences in size of CC for various age groups in both sexes were observed. The mean length of CC was 68.06 mm and mean thickness of CC was 7.81 mm. There were variation in the size of CC with age and sex. The Pearson correlation Coefficient is 0.48829 between Age and Length of CC, its P-value is 0.0019 (Gnawali et al., 2021)

Chapter three

Materials and Methods

Chapter three

Materials and Methods

3.1 Materials:

3.1.1 Patients:

The patient population consist of 51 male and 49 female with age ranging from (25 to 80), normal patient full history taken from each patient. Patients with brain diseases and patient metallic prosthesis.

3.1.2 Study design:

This descriptive study, about the corpus callosum, the main objective were to obtain measurement of corpus callosum, to know the normal measurement, and used this information to diagnosis.

3.1.3 Study Area:

The study was conducted in Khartoum state, included hospitals

1. Almoalem medical city (3 tesla MRI machine Toshiba medical systems).
2. Ahmed Gasim hospital (3 tesla MRI machine Toshiba medical systems).

3.1.4 Study Duration:

The study duration form September to December 2021.

3.1.5 Variables of the study:

The data will be collected depending on the following variables:

Age and gender.

3.1.6 Machine used:

The machine used in this study 3 tesla MRI machine (Toshiba medical systems)

3.2 Methods:

The data were collected from the patient refer to MRI scan, and before scan, weight of PT and height were measured using measuring devised firstly all the patient were prepared remove from any metallic object and enter the room for scan.

3.2.1 Technique:

The patient was scanned supine position on the examination couch with their head within the head coil. The head is adjusted so that the inter-pupillary line is parallel to the couch and the head is straight. The patient is positioned so that the longitudinal alignment light lies in the midline, and the horizontal alignment light passes through the nasion. Straps and foam pads are used for immobilization.

The brain MRI protocol included the following imaging planes: a) sagittal T1-weighted images, b) axial T1-weighted images, c) axial T2-weighted images,d(axial fluid-attenuated inversion recovery (FLAIR) protocol, and e) coronal T2weighted images. Slice thickness/interslice gap of 5/1.5 mm and matrix size of 256×192 were used. (Alnour Badawi et al., 2020)

3.2.2 Image interpretation:

In this study, we measured the longitudinal and vertical dimensions of the corpus callosum and its various parts. For each case, using sagittal T1-weighted image, Length of CC from the most anterior point of the genu to the most posterior point of the splenium. Using the Mohammadi MR1 et al 2011 division method, the longitudinal dimensions of the rostrum, genu, and splenium were measured. The width of the CC middle portion was considered as the body dimension.

3.2.3 Data collection and analyses:

Data collection according to work sheet (appendix1) include figure to show way of measurement. The obtained data were then analyzed using statistical package for the social sciences (SPSS) software program.

3.2.4 Ethical approval:

The data was collected under agreement from the hospitals. All the data and information of the patient will be preserved. The data will be collected after a written consent is signed by the patient.

Chapter four

Results

Chapter four

Results

Table (4.1): Shows frequency distribution of gender:

Gender		Frequency	Percent
Valid	**Male**	51	51%
	Female	49	49%
	Total	100	100%

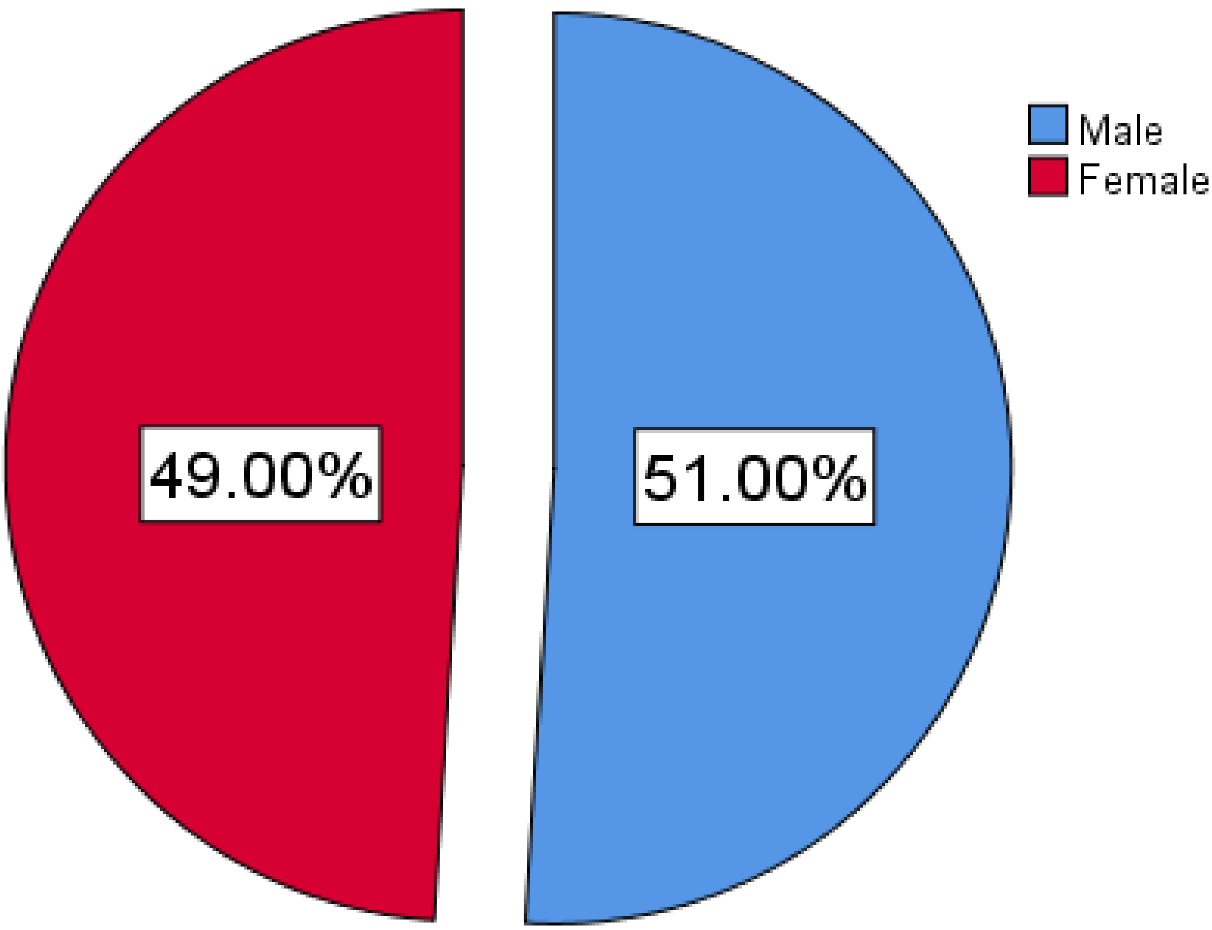

Figure (4.1): Shows frequency distribution of gender

Table (4.2): Shows frequency distribution of age group:

Age group		Frequency	Percent
Valid	**(25-35)**	23	23%
	(36-45)	23	23%
	(46-55)	17	17%
	(56-65)	19	19%
	(>65)	18	18%
	Total	100	100%

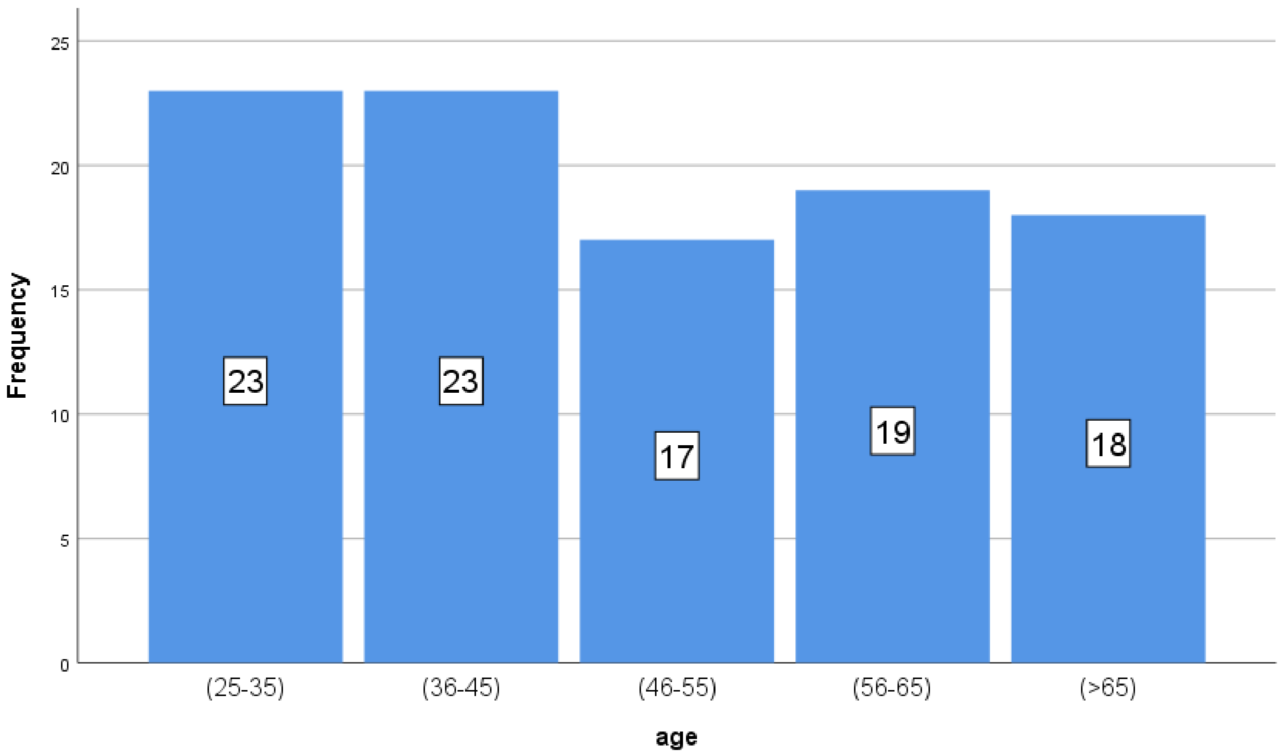

Figure (4.2): Shows frequency distribution of age group

Table (4.3): Shows descriptive statistics of study variables:

	N	Minimum	Maximum	Mean	Std. Deviation
Age (years)	100	25	80	49.53	15.9
Length CC (mm)	100	67	84	75.93	3.91
Thickness of genu(mm)	100	5	15	10.6	1.591
Thickness of body(mm)	100	4	9	6.13	0.92
Thickness of selenium (mm)	100	8	17	11.28	1.51
Thickness of Rostrum (mm)	100	4	13	6.95	1.91

Table (4.4): Shows frequency distribution of correlations for gender and age with measurements:

		Gender	Age
Length CC(mm)	Pearson Correlation	-0.126	-0.027
	Sig. (2-tailed)	0.210	0.790
	N	100	100
Thickness of genu(mm)	Pearson Correlation	0.020	-0.408**
	Sig. (2-tailed)	0.842	0.000
	N	100	100
Thickness of body(mm)	Pearson Correlation	.036	-0.308**
	Sig. (2-tailed)	0.724	0.002
	N	100	100
Thickness of selenium(mm)	Pearson Correlation	0.110	-0.359**
	Sig. (2-tailed)	0.275	0.000
	N	100	100
Thickness of Rostrum(mm)	Pearson Correlation	0.026	-0.201*
	Sig. (2-tailed)	0.799	0.045
	N	100	100

*Correlation is significant at the 0.05 level (2-tailed).
**Correlation is significant at the 0.01 level (2-tailed).

Table (4.5): Shows comparison measurements between gender:

a. **Means:**

	Gender	N	Mean	Std. Deviation
Length CC(mm)	Male	51	76.41	3.64
	Female	49	75.43	4.14
Thickness of genu(mm)	Male	51	10.57	1.35
	Female	49	10.63	1.83
Thickness of body(mm)	Male	51	6.1	0.85
	Female	49	6.16	0.99
Thickness of splenium(mm)	Male	51	11.12	1.35
	Female	49	11.45	1.66
Thickness of Rostrum(mm)	Male	51	6.9	1.95
	Female	49	7	1.89

b. **Independent Samples Test**:

		t-test for Equality of Means			
		t	df	Sig. (2-tailed)	Mean Difference
Length CC (mm)	Equal variances assumed	1.26	98.00	0.21	0.98
	Equal variances not assumed	1.26	95.28	0.21	0.98
Thickness of genu (mm)	Equal variances assumed	-0.20	98.00	0.84	-0.06
	Equal variances not assumed	-0.20	87.92	0.84	-0.06
Thickness of body (mm)	Equal variances assumed	-0.35	98.00	0.72	-0.07
	Equal variances not assumed	-0.35	94.84	0.73	-0.07
Thickness of splenium(mm)	Equal variances assumed	-1.10	98.00	0.28	-0.33
	Equal variances not assumed	-1.09	92.58	0.28	-0.33
Thickness of Rostrum(mm)	Equal variances assumed	-0.26	98.00	0.80	-0.10
	Equal variances not assumed	-0.26	97.99	0.80	-0.10

Table (4.6): Shows ANOVA test for comparison measurements between age groups:

		Sum of Squares	df	Mean Square	F	Sig.
Length CC(mm)	Between Groups	49.9	4.0	12.5	0.8	0.5
	Within Groups	1460.7	95.0	15.4		
	Total	1510.5	99.0			
Thickness of genu(mm)	Between Groups	45.7	4.0	11.4	5.3	0.0
	Within Groups	206.3	95.0	2.2		
	Total	252.0	99.0			
Thickness of body(mm)	Between Groups	9.2	4.0	2.3	2.9	0.0
	Within Groups	74.1	95.0	0.8		
	Total	83.3	99.0			
Thickness of splenium(mm)	Between Groups	30.0	4.0	7.5	3.6	0.0
	Within Groups	196.2	95.0	2.1		
	Total	226.2	99.0			
Thickness of Rostrum(mm)	Between Groups	35.8	4.0	9.0	2.6	0.0
	Within Groups	326.9	95.0	3.4		
	Total	362.8	99.0			

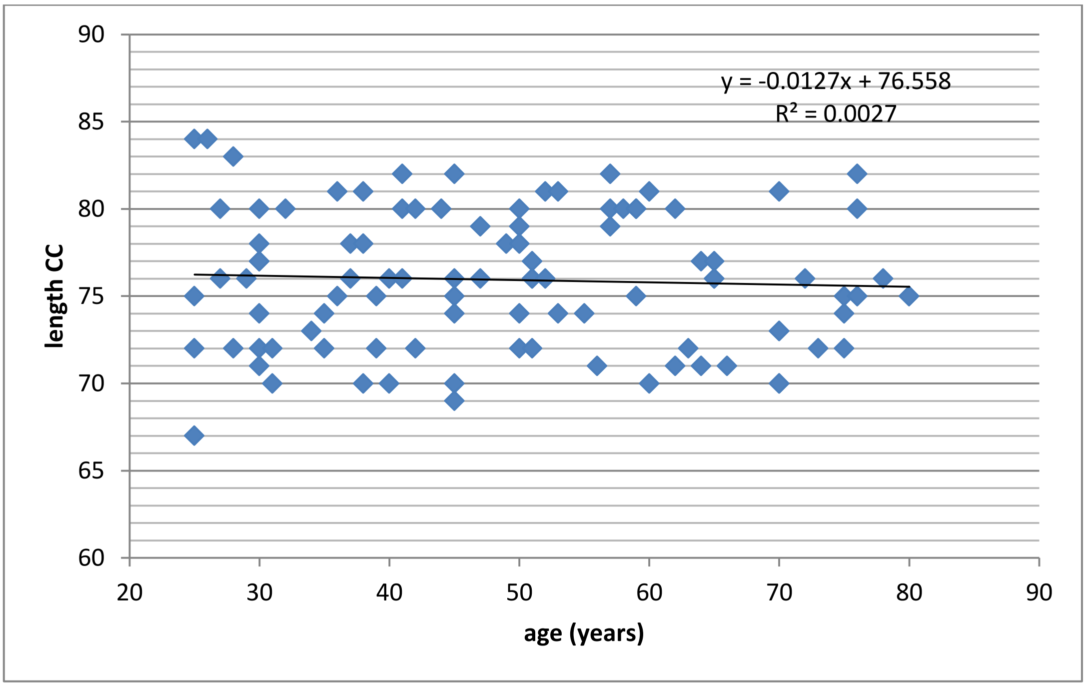

Figure (4.3): scatter plot shows linear relation between age (years) and length CC (mm)

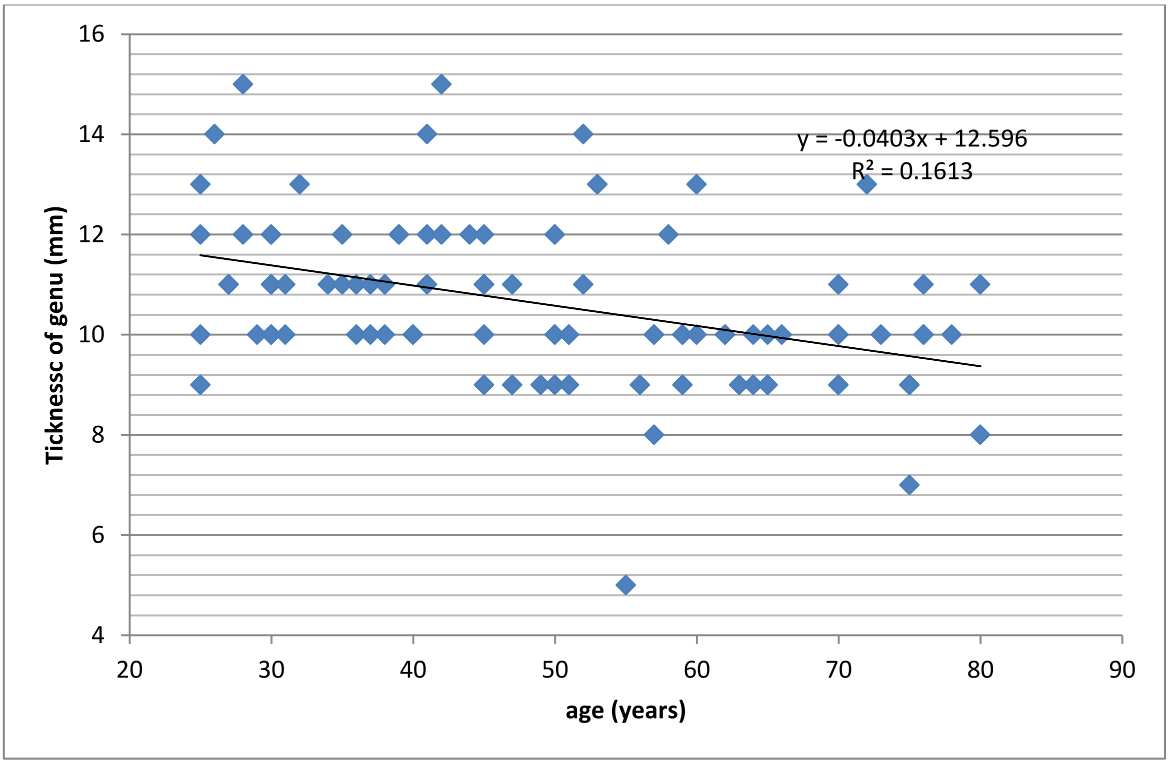

Figure (4.4): scatter plot shows linear relation between age (years) and thickness of genu (mm)

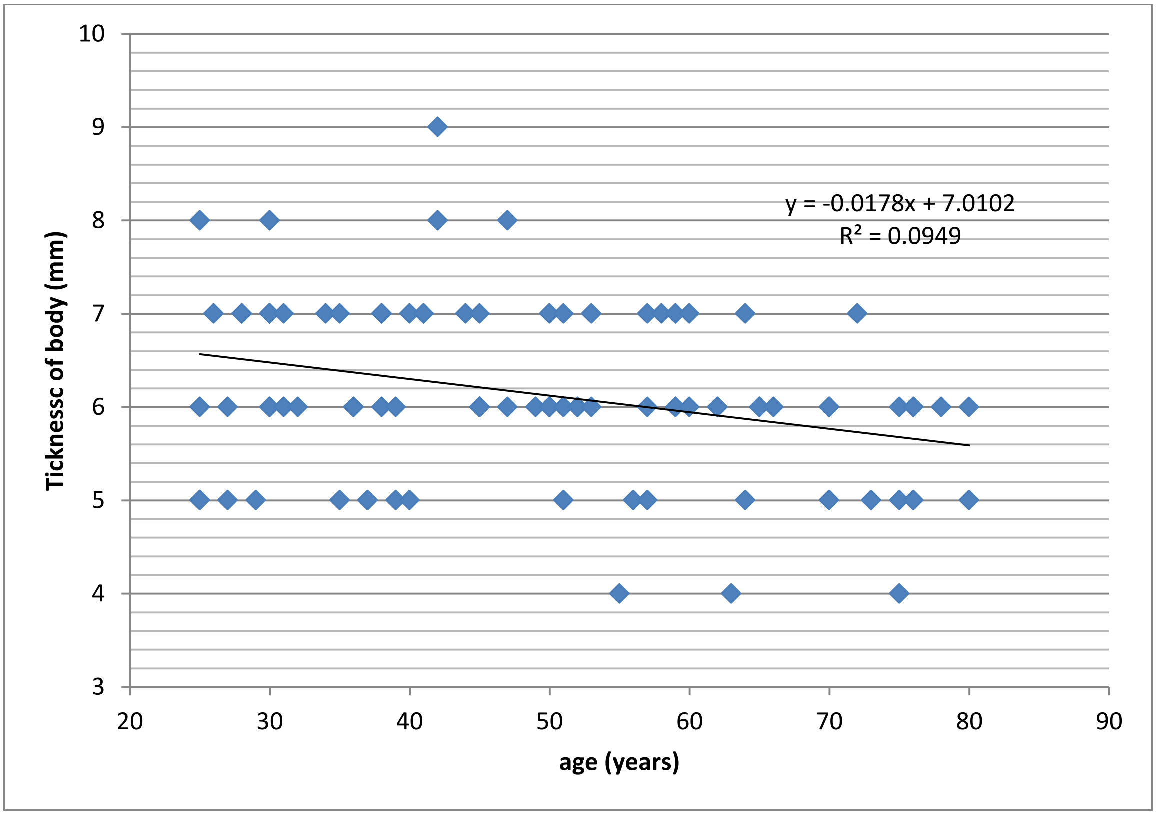

Figure (4.5): scatter plot shows linear relation between age (years) and thickness of body (mm)

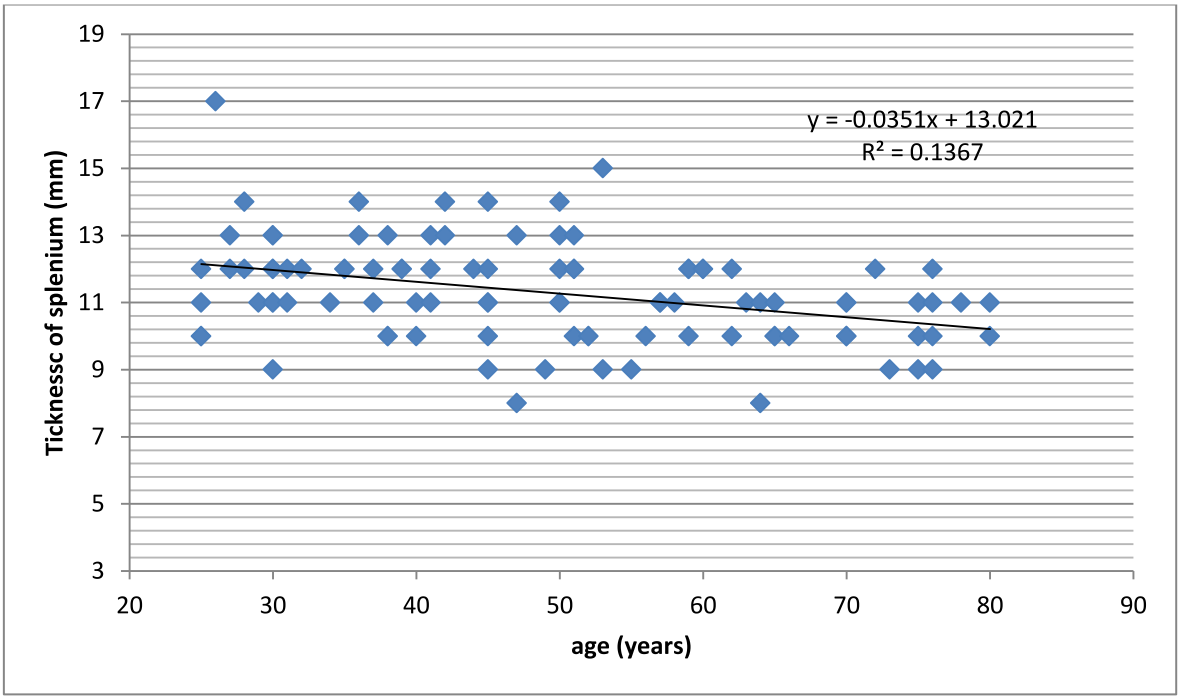

Figure (4.6): scatter plot shows linear relation between age (years) and thickness of splenium (mm)

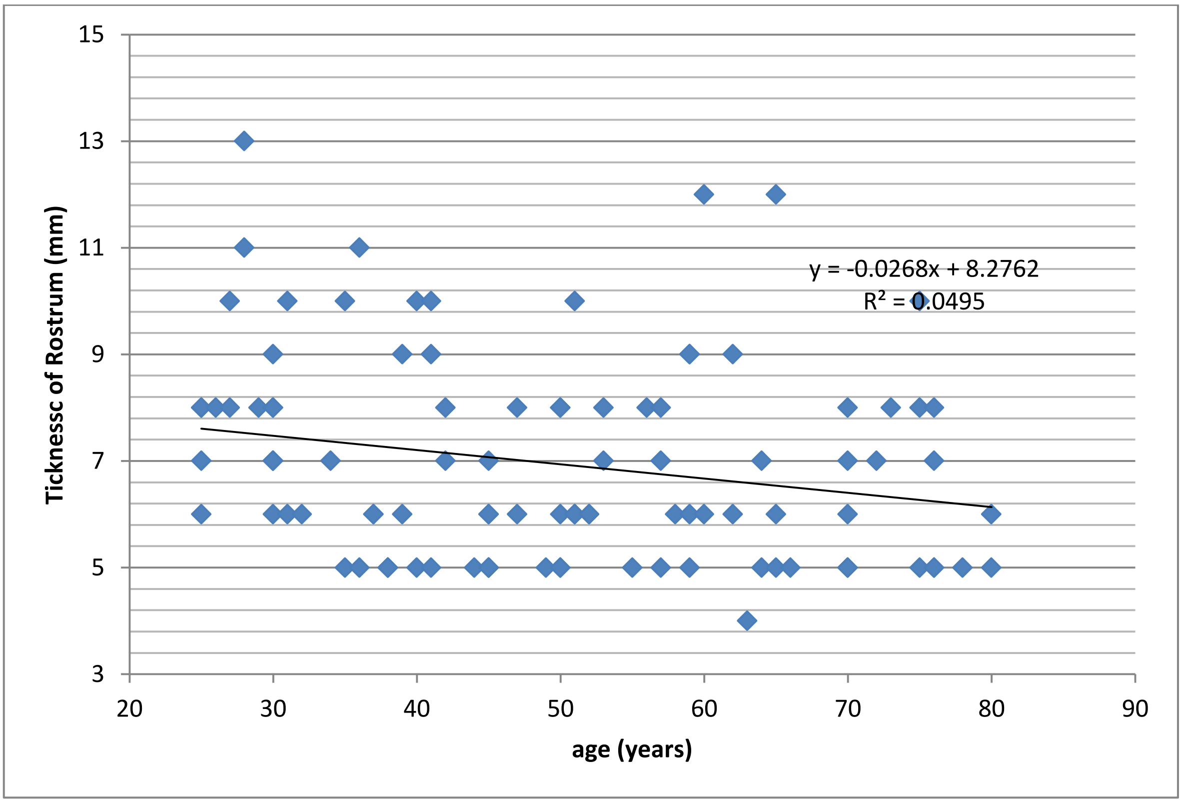

Figure (4.7): scatter plot shows linear relation between age (years) and thickness of rostrum (mm)

Chapter five

Discussion, Conclusion and Recommendations

Chapter five

Discussion, Conclusion and Recommendations

5.1 Discussion:

This study was conducted in almoalem hospital and Ahmed gasim hospital. Constitutes of 100 patients having normal corpus callosum in the adult. The sample was classified according to the gender males (51%) and females (49%) and this in table, figure (4.1). with percentage of male more than female, this is same result that obtained by Alnour Badawi et al., 2020 and present the percentage of male (50.9%) and female (49.1%).

The study found most patients in age groups (25-35), (36-45) (were 23%) for each one, (56-65) were (19%), (>65) were (18%) and (46-55) were (17%). table, figure (4.2).

The study found from with a mean of (49.53±15.9) years length cc, genu, splenium, body and rostrum thickness were (75.93±3.91) mm, (10.6±1.591) mm, (6.13±0.92) mm, (11.28±1.51) mm and (6.95±1.91) mm. table (4.3).This finding similar to Alnour Badawi et al., 2020 we found the longitudinal dimensions of the CC, genu, splenium, and body width were 74.23±5.12 mm, 10.92±1.6 mm, 10.92±1.47 mm, and 5.43±0.89 mm.

The study found there was statistically significant correlation between age and [genu, splenium, body and rostrum thickness] (p-values < 0.05), statistically insignificant correlation between age and length CC (p-values > 0.05) and between gender and [length CC, genu, splenium, body and rostrum thickness] (p-values > 0.05). table (4.4).

There was statistically insignificant difference between male and female in [length CC, genu, splenium, body and rostrum thickness] (sig. > 0.05), with mean for males (76.41±3.64), (10.57±1.35), (6.1±0.85), (11.12±1.35) and (6.9±1.95) mm respectively and means for females (75.43±4.14), (10.63±1.83), (6.16±0.99), (11.45±1.66) and (7±1.89) mm respectively. table (4.5). similar to the results obtain by tagreed, (2017) for the Sudanese population we found the study concluded no significant difference in corpus callosum between both genders measurement in corpus callosum index and disagree with mohammedi et al (2011).found that the longitudinal dimensions of CC, genu, and splenium were larger in males than in females, but these differences were not significant.

There was statistically significant difference between age groups in [genu, splenium, body and rostrum thickness]

There was statistically significant difference between age groups in [length CC, genu, splenium, body and rostrum thickness] (sig. < 0.05). table (4.6).

The results found that there was negative linear relation between age (years) and length CC (mm) ($R^2 = 0.0027$), between age (years) and thickness of genu (mm) ($R^2 = 0.1613$), between age (years) and thickness of body (mm) ($R^2 = 0.0949$), between age (years) and thickness of splenium (mm) ($R^2 = 0.1367$) and between age (years) and thickness of rostrum (mm) ($R^2 = 0.0495$). figures (4.3) to (4.7).

5.2 Conclusion:

This study about corpus callosum in normal Sudanese population using MRI T1 weighted imaging to give better accurate estimate of normal measurement to use this information to diagnosis. As the result was there was statistically significant correlation between age and [genu, splenium, body and rostrum thickness], insignificant difference in corpus callosum between both male and female in measurements, statistically significant difference between age groups in measurements and there was negative linear relation between age (years) and corpus callosum measurements

5.3 Recommendations:

-To study the measurement in large group of patient.

-Used the MRI machine for measurement compare with other modalities.

-measure meant of corpus callosum in pediatric compare with adult using MRI.

-To study measure distribution according to age.

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Appendices

Appendix (A)

Sudan University of science and technology

College of Graduate studies

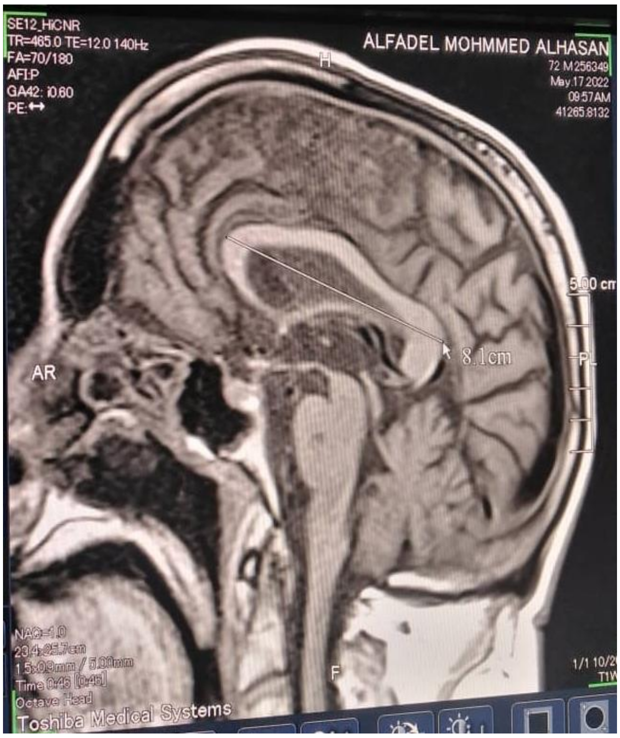
Estimation of the normal corpus callosum in adult using magnetic imaging resonance

Data collecting sheet

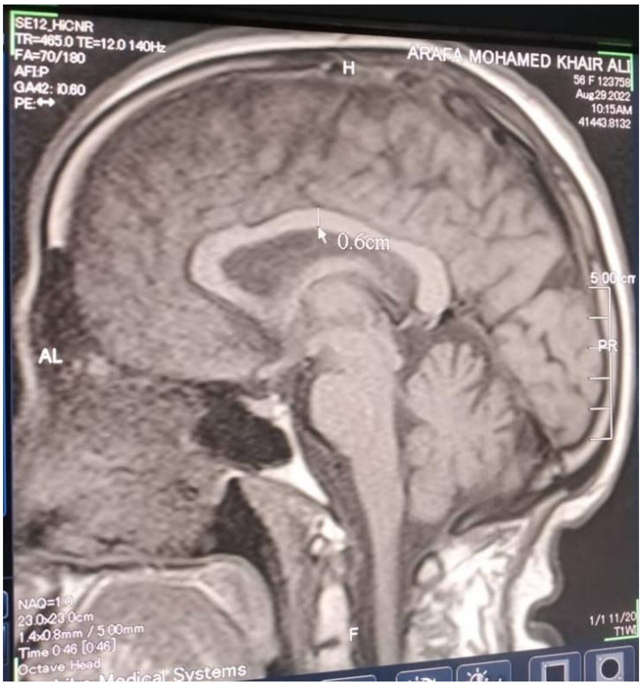
Number	Gender	age	Length CC (APD)	Thickness of genu (GT)	Thickness of body (BT)	Thickness of splenium (ST)	Thickness of rostrum(RT)

Appendix (B)

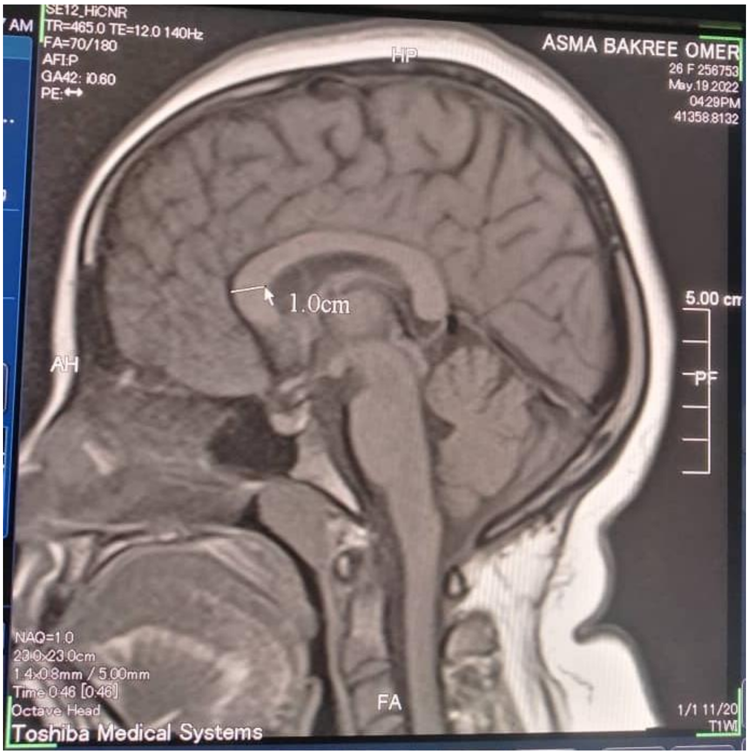
MRI Images



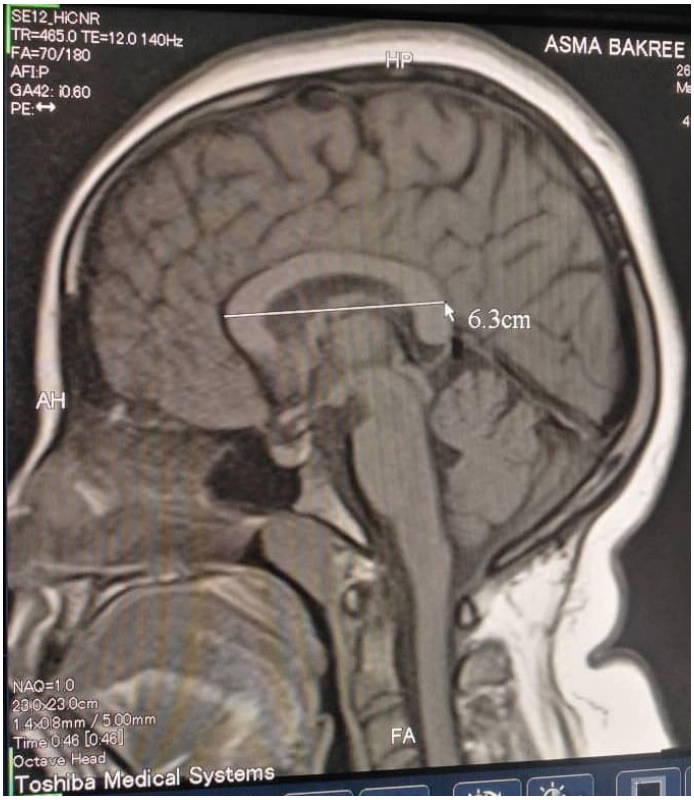
In figure (1) male 72 age years old the measure of the CC starting from genu until splenium (8.1cm)*10 (81mm)



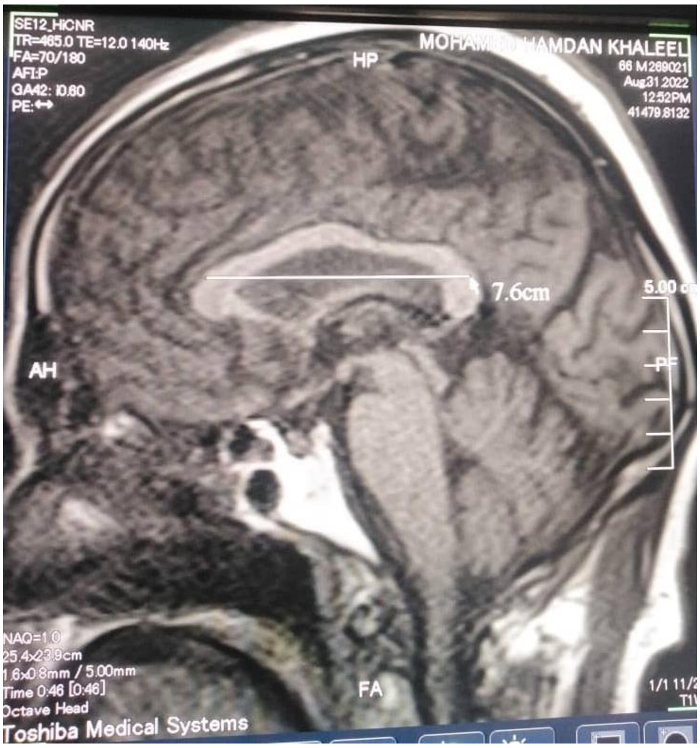
In figure (2) female 56 age years old the body was taken to measure vertical line (0.6cm)*10 (6mm)



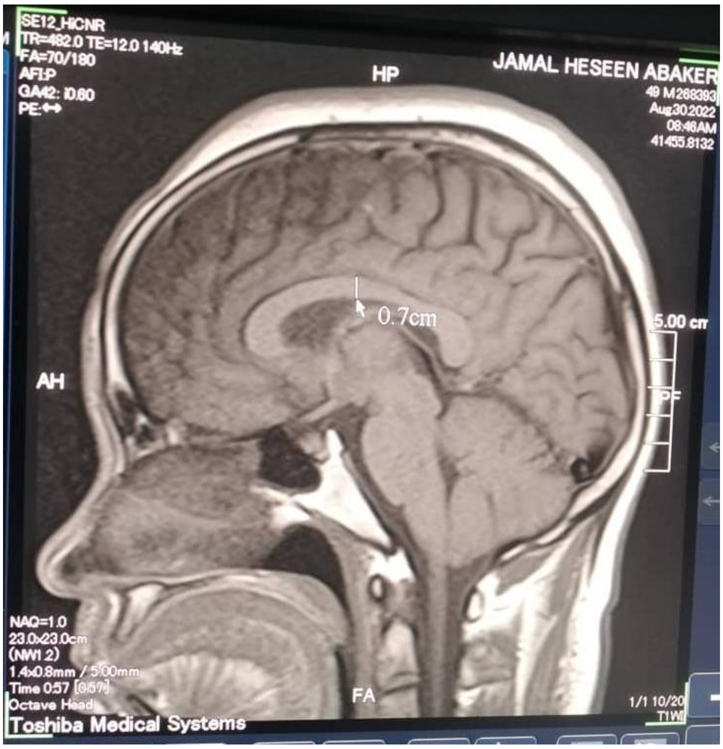
In figure (3) female 26 age years old the genu was taken to measure longitudinal line (1.0cm)*10 (10mm).



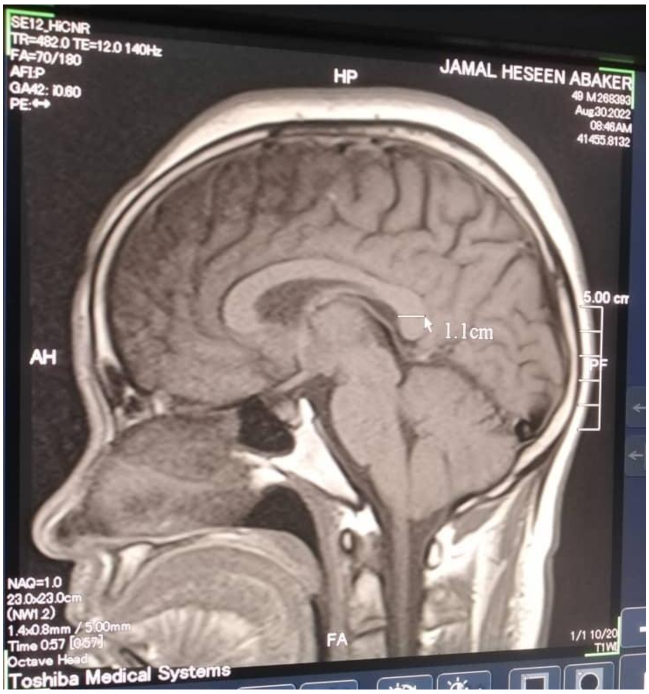
In figure (4) female 26 age years old the measure of the CC starting from genu until splenium (6.3cm)*10 (63mm)



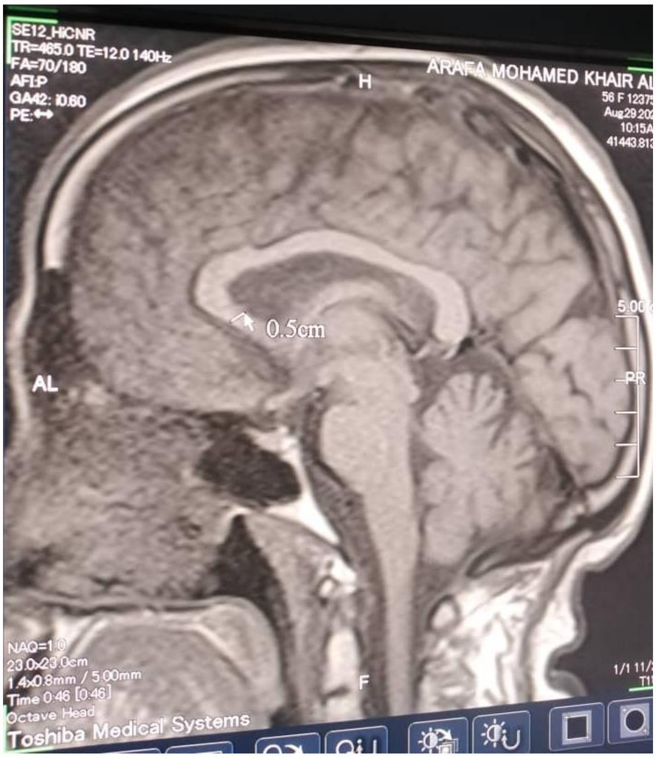
In figure (5) male 66 age years old the measure of the CC starting from genu until splenium (7.6cm)*10 (76mm)



In figure (6) male 49 age years old the body was taken to measure vertical line (0.7cm)*10 (7mm)

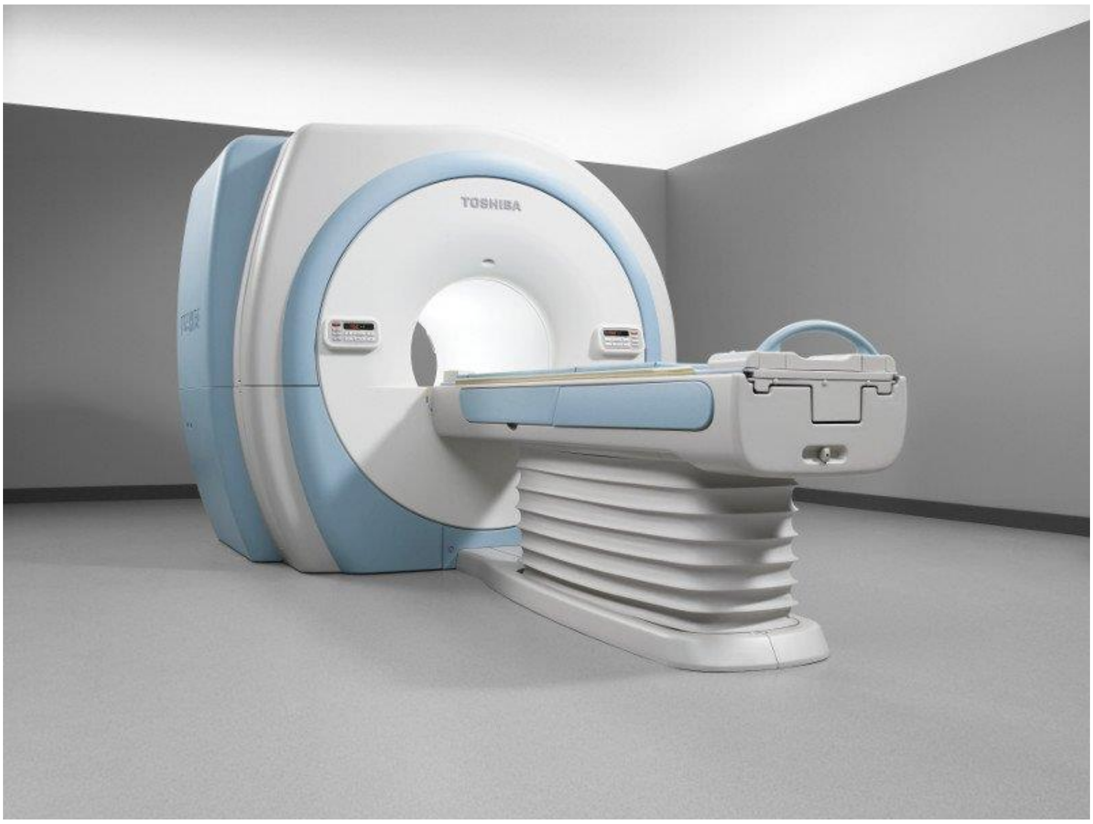


In figure (7) male 49 age years old the splenium was taken to measure longitudinal line (1.1cm)*10 (11mm).



In figure (8) female 56 age years old the rostrum was taken to measure longitudinal line 0.5cm)*10 (5mm).

In figure (9) female 26 age years old the splenium was taken to measure longitudinal line (0.9cm)*10 (9mm).



In figure (10) 3 tesla MRI machine (Toshiba medical systems)