DOI: 10.7860/IJARS/2022/51289.2780

Original Article

Radiology Section

Corpus Callosal Morphometry in Mid-sagittal Plane MRI in Patients of Different Age Groups: A Retrospective Study

VADANA BALA MURALI KRISHNA[1], KONDRAGUNTA CHANDRA SEKHAR[2], DASARI PRAVALLIKA[3], THOTA CHANDANA[4]

ABSTRACT

Introduction: Corpus callosum is the largest and most important of the forebrain commissural tracts connecting the two cerebral hemispheres. This white matter tract plays essential role in sensory, motor and cognitive signal transmission across the right and left cerebral hemispheres. Hence, corpus callosal thickness and morphology reflects the hemispheric volume and functional ability of the brain. Thinning of corpus callosum which can be due to abnormal or absent myelination, demyelinating conditions, hypoxic ischaemic encephalopathy and metabolic diseases affecting the white matter can lead to developmental impairment and behavioural disorders which need to be properly evaluated.

Aim: To identify possible age-associated variability in the anteroposterior diameter and the thickness of different parts of the corpus callosum.

Materials and Methods: A retrospective cross-sectional study of 420 patients over a period of two years from January 2019 to December 2020 done at Dr. PSIMS and RF, Gannavaram, Andhra Pradesh, India. Magnetic Resonance (MR) examinations were performed with 1.5T (Philips Healthcare) Magnetic Resonance Imaging (MRI) scanner. The subjects who underwent MRI for various suspected or known central nervous system diseases were included in the study. The thickness of various parts along with the anteroposterior diameter of the corpus callosum were measured with mid-sagittal T1 weighted MR sequence and the mean and standard deviation was calculated.

Results: The anteroposterior diameter of the corpus callosum was more in older adults (61-70 years age group) than in children and younger adults. The mean thickness of genu, body and isthmus was found to be more in younger adults (21-30 years age group), whereas thickness of splenium was more in the age group of 31-40 years.

Conclusion: The anteroposterior diameter was more in the elderly age group, whereas the thickness of corpus callosal regions was more in the young adult age group. Therefore, variations in corpus callosal thickness would help in the diagnosis of disease presence and progression.

Keywords: Anteroposterior diameter, Body, Genu, Isthmus, Magnetic resonance imaging, Splenium

INTRODUCTION

The corpus callosum is the largest bundle of commissural fibers in the human brain [1]. Anatomically, the corpus callosum comprises five parts- rostrum, genu, body, isthmus and splenium [2]. Genu is the most anterior region connecting the lateral and medial frontal lobes, while the splenium is the most posterior region. Body is the longest segment of corpus callosum, while isthmus is shorter and narrower area that lies between the posterior body and splenium. The genu connects the lateral and medial frontal lobes. The body connects the regions of each hemispheric cortex and these fibers intersect with corona radiata. The isthmus connects the pre and postcentral gyri and auditory cortex of both hemispheres with their respective counterparts. Therefore, morphological changes in corpus callosum may aid in diagnosis and progression of disease [3].

Mid-sagittal T1 MR sequences provide the best visualisation and quantitative assessment of thickness of various parts of corpus callosum [4]. Thickness of the corpus callosum alters in various conditions such as white matter diseases like multiple sclerosis, dementia, tumours, cerebrovascular diseases, infections such as Human Immunodeficiency Virus (HIV) infection and Acquired Immune Deficiency Syndrome (AIDS), chemotherapy, determination of handedness, Autism etc., hence the thickness of various corpus callosal parts provide clue about the severity of the white matter abnormalities as the corpus callosum is the major commissural tract and significant volume loss also indicate age related changes. Several previous studies revealed that there was variation in corpus callosal morphology with age, gender and in certain conditions like bipolar disorders, vascular dementia, Alzheimer's disease, Williams syndrome and other disease processes [2,5].

This study aimed at examining the morphology and provides the mean values of both the sexes in a wide range of age groups from the 1st-6th decade. Not many studies that have done this have provided the mean values of the corpus callosal subregions. This study had characterised age associated variations according to the subregion of corpus callosum across a wide range of age groups in a large study population of 420 subjects.

MATERIALS AND METHODS

This was a cross-sectional retrospective study of 420 patients over a period of two years from January 2019 to December 2020 at Dr. PSIMS and RF, Gannavaram, Vijayawada, Andhra Pradesh, India. Informed consent was taken from all the patients with clearance from the Ethical Committee of the Institute (IEC approval reference number 666A/21).

Inclusion criteria: Patients who were referred to MRI for evaluation of headaches, seizures, balance disorders, trigeminal neuralgia, visual abnormalities in which MRI was normal were included in the study. Old age patients who underwent MRI for various causes with mild periventricular ischaemic changes which were age related were also included in the study.

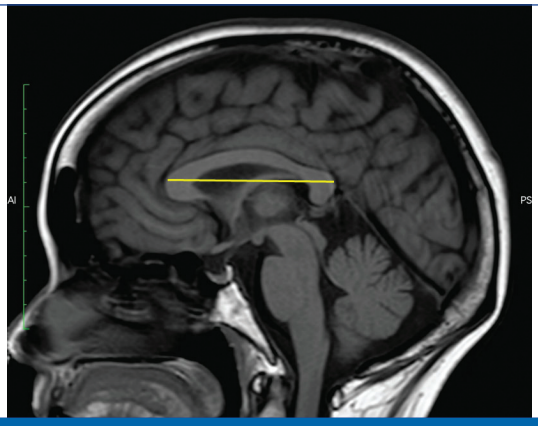
Exclusion criteria: Patients with hydrocephalus, trauma, space occupying lesions, demyelinating/dysmyelinating disorders, inborn errors of metabolism, Infarcts causing volume loss and pathologic processes that could affect morphology of the corpus callosum were excluded from the study.

Imaging Protocol and Analysis

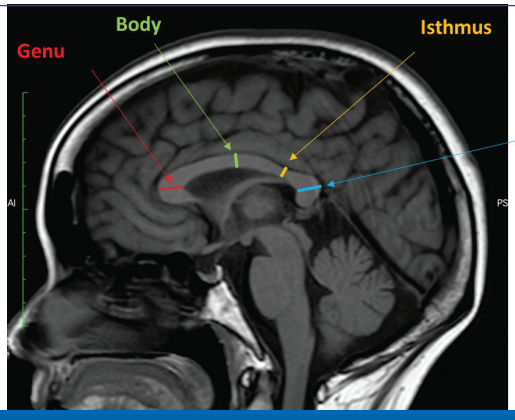
Conventional sagittal T1 weighted turbo spin echo images were used for the analysis as this sequence gives accurate anatomy of

the mid-sagittal section corpus callosum and is routinely done in all the brain studies in this institute. The scanning parameters were as follows; TR: 400 msec, TE: 8.0 msec, FOV: 353 mm, matrix size: 288×288, slice thickness of 5 mm.

The corpus callosal thickness from various parts-genu, body, isthmus and splenium, along with the anteroposterior diameter of the corpus callosum were measured with mid-sagittal T1 weighted MR sequence. Anteroposterior diameter of corpus callosum-distance between the anterior aspect of the genu and the posterior aspect of the splenium along with thickness of various parts of corpus callosum at their maximum level were analysed in millimeters (mm) [3] [Table/Fig-1,2].



[Table/Fig-1]: Mid-sagittal T1W MR image showing the measurement of the anteroposterior diameter of the corpus callosum as the distance between the anterior aspect of the genu and the posterior aspect of the splenium.



[Table/Fig-2]: Mid Sagittal T1W MR image showing the measurement of the thickness of various parts of corpus callosum at their maximum level.

STATISTICAL ANALYSIS

The mean and standard deviation of anteroposterior diameter of corpus callosum along with thickness of various regions of corpus callosum of each categorised age group was obtained.

RESULTS

The study subjects were categorised according to their age into seven groups i.e., age groups of 1-10 years, 11-20 years, 21-30 years, 31-40 years, 41-50 years, 51-60 years and 61-70 years. The number of subjects included in each group was 60 [Table/Fig-3].

The range, mean and standard deviation of anteroposterior diameter and various parts of corpus callosum was tabulated in [Table/Fig-4] and the parameters according to different age groups is shown in [Table/Fig-5].

The anteroposterior diameter of all the age groups ranged from a minimum of 52.26 mm to a maximum of 86.46 mm with the mean measured value of 69.59±5.59 mm standard deviation. The age group of 61-70 years had the highest anteroposterior diameter with the mean value of 72.75 mm whereas the least mean value was 62.86 mm seen in age group of 1-10 years. The mean measured thickness values of genu, body, isthmus and splenium of all age groups were 10.47±1.76 mm, 5.36±0.98 mm, 4.33±0.84 mm and 10.03±1.58 mm, respectively.

Age (years)	1-10	11-20	21-30	31-40	41-50	51-60	61-70
No. of patients	60	60	60	60	60	60	60

[Table/Fig-3]: Age distribution.

Parameters (mm)	Range	Mean±SD
Anteroposterior diameter	52.26-86.46	69.59±5.59
Genu	3.87-15.91	10.47±1.76
Body	2.32-9.67	5.36±0.98
Isthmus	2.03-7.31	4.33±0.84
Splenium	5.29-14.21	10.03±1.58

[Table/Fig-4]: The range, mean and standard deviation of anteroposterior diameter and various parts of corpus callosum.

Parameters (mm)	Age groups (years)	Mean	Standard deviation
Anteroposterior diameter	1-10	62.86	4.49
	11-20	67.37	4.36
	21-30	69.11	4.47
	31-40	71.72	4.64
	41-50	71.52	4.28
	51-60	71.81	4.64
	61-70	72.75	5.11
	Total	69.59	5.58
Genu	1-10	9.42	1.98
	11-20	10.23	1.76
	21-30	11.23	1.69
	31-40	11.20	1.60
	41-50	10.94	1.45
	51-60	10.57	1.43
	61-70	9.72	1.47
	Total	10.47	1.75
Body	1-10	5.00	1.08
	11-20	5.66	0.88
	21-30	5.57	0.93
	31-40	5.55	1.00
	41-50	5.39	0.91
	51-60	5.35	0.95
	61-70	4.99	0.87
	Total	5.36	0.977
Isthmus	1-10	3.85	0.8
	11-20	4.46	0.76
	21-30	4.55	0.95
	31-40	4.47	0.77
	41-50	4.50	0.81
	51-60	4.41	0.84
	61-70	4.08	0.68
	Total	4.33	0.84
Splenium	1-10	8.35	1.53
	11-20	10.32	1.43
	21-30	10.45	1.62
	31-40	10.72	1.25
	41-50	10.29	1.26
	51-60	10.21	1.40
	61-70	9.87	1.35
	Total	10.03	1.58

[Table/Fig-5]: Mean and standard deviation of parameters in different age groups.

The mean thickness of genu and isthmus was found to be more in younger adults (21-30 years age group) with mean values of 11.23 and 4.55 mm, respectively. The mean thickness of the body (5.66 mm) was more in the age group 11-20 years, whereas the mean thickness of splenium (10.72 mm) was more in the age group of 31-40 years.

DISCUSSION

Corpus callosum being the essential interhemispheric white matter tract is likely to be affected by both physiologic and pathologic process that occur in the cortical and subcortical regions [3,6]. The mean values of anteroposterior diameter of corpus callosum showed a gradual increase with increase in age with a mean of 72.75 mm in the age group of 61-70 years. However, in a study of 100 patients by Suganthy J et al., there was significant increase in the length of the corpus callosum with age in both males and females, with a mean value of 72.6 mm in age group of >60 years [6]. In another study by Allouh MZ et al., significantly small anteroposterior lengths of the Corpus callosum was found in children (2-10 years) than in younger (20-45 years) and older adults (55-80 years) with mean values of 60.5±5.3 mm, 68.4±4.0 mm and 69.5±4.1 mm, respectively [1]. In other study by Guz W et al., which included 10 age groups, this parameter showed a gradual increase in mean values as the age progresses with a mean value of 68.93±4.5 mm in age group of 61-70 years [7]. However, the mean values in this age group in the present study were slightly higher measuring 72.75±5.11 mm. In this study, the mean thickness values of genu showed a gradual increase followed by a plateau at age of 20-40 years and thereby decreased in thickness.

In the present study, the maximum mean thickness of the body was seen in the age group of 11-20 years, thereby a gradual decrease in the thickness was seen with the increasing age, with a least mean value of 4.99 mm in the age group of 61-70 years. In a study of 121 patients by Jain A et al., found significant decrease in width especially of genu and body with increasing age [2]. Gupta T et al., concluded that the width of corpus callosal body was more in young age group of 20-40 years when compared to the older age group of >40 years [8]. Also, the width of the genu and trunk decreased with age in males [6]. The mean thickness of the isthmus showed a gradual increase from 1-10 years till the age of 30 years and thereby decreased with increasing age. In a study by Tanaka-Arakawa MM et al., that included the infant, children and adult age groups, the mean thickness of the isthmus was found to be more in the adult age group of 18-25 years [9].

In this study, the corpus callosal thickness was more in young adults of age groups 21-30 and 31-40 years. Sullivan EV et al., reported statistically significant thinning of genu, body and splenium with age on MRI study of mid sagittal brain sections. As the corpus callosum is located adjacent and superior to the lateral ventricle, these changes have been speculated to be due to lateral ventricle expansion in elderly [10]. In the present study, there was significant decrease in genu, body and splenium as well with increasing age.

The present study provides a better understanding of various corpus callosal parameters according to their subregions in a large group of subjects and wide range of age groups and may have implications for future investigations regarding the structural and morphological alterations. The corpus callosal morphometry in this study was based on the gross anatomy, hence Diffusion Tensor Imaging (DTI) may be an adjuvant technique for assessing the corpus callosal properties along with the morphometry.

It is also observed that the mean values of anteroposterior diameter of the corpus callosum in elderly age groups of 51-60 years and 61-70 years associated with Fazeka Grade I ischaemic disease ranged from minimum of 64.8 to a maximum of 82.4 mm and those of with Fazeka Grade II ischaemic disease ranged from 60.5-83.3 mm and with Fazeka Grade III, the mean values ranged from 76.0 to 84.4 mm [11]. Therefore, the mean anteroposterior diameter of the corpus callosum can be an indirect indicator of age related severity of the atherosclerotic disease. However, this requires further study for better evaluation.

Limitation(s)

The present study was limited by certain factors. No neonatal cases were included in the study population and the gender related variations were not assessed. Volume of corpus callosum was not included in the morphometry.

CONCLUSION(S)

This study showed that there is variability in the thickness and anteroposterior length of corpus callosum in accordance to age. The anteroposterior length increased with increase in age and was more in the elderly age group of >60 years. The thickness of various regions of corpus callosum was more in the younger adult age group than in the children, adolescent and older age groups.

REFERENCES

[1] Allouh MZ, Al Barbarawi MM, Ali HA, Mustafa AG, Alomari SO. Morphometric analysis of the corpus callosum according to agend sex in Middle Eastern Arabs: Racial comparisons and clinical correlations to autism spectrum disorder. Front Syst Neurosci. 2020;14:30.

[2] Jain A, Naik D, Sundari A, Kumar AA. Age and gender related changes in the dimensions of corpus callosum by MRI-in south Indian population. International Journal of Anatomy, Radiology and Surgery. 2017;6(3):47-51.

[3] Gupta E, Lalwani R, Babu C, Aneja S. Age related changes of corpus callosum by MRI in females. The Internet Journal of Neurology. 2003;13(1):1.

[4] Garel C, Cont I, Albert C, Josserand E. Biometry of the corpus callosum in children: MR imaging reference. AJNR Am J Neuroradiol. 2011;32:1436-43.

[5] Mohammadi MR, Zhand P, Mortazavi Moghadam B, Golalipour MJ. Measurement of the corpus callosum using magnetic resonance imaging in the North of Iran. Iranian Journal of Radiology. 2011;8(4):218-23.

[6] Suganthy J, Raghuram L, Antonisamy B, Vettivel S, Madhavi C, Koshi R. Gender and age related differences in the morphology of the corpus callosum. Clin Anat. 2003;16:396-403.

[7] Guz W, Pazdan D, Stachyra S, Swiatón F, Porêba P, Bednarz M, et al. Analysis of corpus callosum size depending on age and sex. Folia Morphol. 2019;78:24-32.

[8] Gupta T, Singh B, Kapoor K, Gupta M, Kochhar S. Age and sex related variations in corpus callosal morphology. Nepal Med Coll J. 2008;10(4):215-21.

[9] Tanaka-Arakawa MM, Matsui M, Tanaka C, Uematsu A, Uda S, Miura K, et al. Developmental changes in the corpus callosum from infancy to early adulthood: A structural magnetic resonance imaging study. PLoS ONE. 2015;10(3):e0118760.

[10] Sullivan EV, Pfefferbaum A, Adalsteinsson E, Swan GE, Carmelli D. Differential rates of regional brain change in callosal and ventricular size: A 4 year longitudinal study of elderly men. Cereb Cortex. 2002;12:438-45.

[11] Fazekas F, Chawluk JB, Alavi A, Hurtig HI, Zimmerman RA. MR signal abnormalities at 1.5 T in Alzheimer's dementia and normal aging. AJR Am J Roentgenol. 1987;149(2):351-56.

PARTICULARS OF CONTRIBUTORS:

1. Associate Professor, Department of Radiology, Dr. Pinnamaneni Siddhartha Institute of Medical Sciences and Research Foundation, Chinnavutapally, Gannavaram, Krishna District, Andhra Pradesh, India.
2. Professor and Head, Department of Radiology, Dr. Pinnamaneni Siddhartha Institute of Medical Sciences and Research Foundation, Chinnavutapally, Gannavaram, Krishna District, Andhra Pradesh, India.
3. Resident, Department of Radiology, Dr. Pinnamaneni Siddhartha Institute of Medical Sciences and Research Foundation, Chinnavutapally, Gannavaram, Krishna District, Andhra Pradesh, India.
4. Resident, Department of Radiology, Dr. Pinnamaneni Siddhartha Institute of Medical Sciences and Research Foundation, Chinnavutapally, Gannavaram, Krishna District, Andhra Pradesh, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Dasari Pravallika,
Resident, Department of Radiology, Dr. Pinnamaneni Siddhartha Institute of Medical Sciences and Research Foundation, Chinnavutapally, Gannavaram-521101, Krishna District, Andhra Pradesh, India.
E-mail: dasari.pravallika3@gmail.com

PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: Jul 14, 2021
- Manual Googling: Jan 04, 2022
- iThenticate Software: Feb 24, 2022 (7%)

ETYMOLOGY: Author Origin

AUTHOR DECLARATION:
- Financial or Other Competing Interests: None
- Was Ethics Committee Approval Obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. Yes

Date of Submission: **Jul 12, 2021**
Date of Peer Review: **Sep 17, 2021**
Date of Acceptance: **Jan 12, 2022**
Date of Publishing: **Apr 01, 2022**