

Measurement of Corpus Callosum Size Using MRI In Nepalese Population

Suman Gnawali ^{*1,2}, Ajay Kumar Yadav ¹, Mukunda Psd Humagain ², Prakash Kayastha ², Durga Panthi ³.

^{*1} Department of Radio diagnosis, Imaging and Nuclear Medicine, B.P.Koirala Memorial Cancer Hospital, Chitwan, Nepal.

² Department of Radiology & Imaging, TU Teaching Hospital, Kathmandu, Nepal.

³ Institute of Medicine, Central Department Of Public Health, Kathmandu, Nepal.

ABSTRACT

Corpus callosum (CC) is the main fiber tract connecting the cortical and sub-cortical regions of the right, left hemispheres, and plays an essential role in the integration of information between the two hemispheres. By using magnetic resonance imaging (MRI), 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

KEY WORD: Magnetic Resonance Imaging (MRI), Corpus callosum (CC), Genu, Body, Splenium Sagittal Spin-Echo.

Corresponding Author: Suman Gnawali, Department of Radio diagnosis, Imaging and Nuclear Medicine, B.P.Koirala Memorial Cancer Hospital, Chitwan, Nepal.

E-Mail: suman.gnawali987@gmail.com

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INTRODUCTION

The corpus callosum (CC) with more than 300 million fibers is the most important anatomical and functional inter-hemispheric commissure in the human brain. The activities of the left and right cerebral hemispheres correlate via CC. Callosal fibers have a special topographic organization. It means that the prefrontal cortex of the right and left human cerebral hemispheres correlate via genu and

rostrum. Besides, premotor and supplementary motor cortical areas, primary motor and primary sensory cortex of the two hemispheres link via the body of the CC; whereas, parietal, temporal and occipital fiber bundles of the two hemispheres cross the CC through the splenium [1].

Corpus callosum has a special influence on the affective behavior, non-literal language and bilateral functional connection in both motor

and sensory cortices. Several studies have reported that the size of CC changes in bipolar disorders, Alzheimer disease, leukoaraiosis and Williams syndrome. Indeed, some researchers have reported that the morphology of CC may change in diseases such as dyslexia Tourette's syndrome, Down's syndrome, depression, schizophrenia and HIV/AIDS [1,2].

Regarding differences in the size of organs in humans including CC according to race/ethnicity in various parts of the world, CC dimensions, morphology and sex-related differences have been of interest to researchers. By using magnetic resonance imaging (MRI), the dimensions of CC including size, diameters, age morphology and also gender-related differences have been determined in several studies. The Objective of this study is to measure the size of corpus callosum using MRI.

IMAGING OF CC

ULTRASONOGRAPHY OF CC: The corpus callosum (CC) is the largest commissural pathway connecting the two cerebral hemispheres. It develops relatively late during cerebral ontogenesis, not assuming its definitive shape until 20 weeks of gestation, and continues to grow well after delivery. Therefore, a proper prenatal sonographic evaluation can be performed only after 20 weeks. Ideally, the CC is assessed on ultrasound by direct visualization. It is a thin band of white-matter fibers and is not depicted using a standard axial plane. It can be seen in the coronal plane, but is only demonstrated in its entire length by using mid-sagittal views, that represent the gold standard for diagnosing abnormalities of this structure. Visualization of coronal and mid-sagittal planes requires technical skill, and is not recommended in standard examinations of low-risk pregnant patients. Reference ranges of fetal CC dimensions have been published and can be used to assess normal and deviant development. There is a general consensus that diagnosing CC abnormalities is difficult. In standard examinations, absence of the CC may be detected because of either indirect cerebral findings, such as ventriculomegaly,

absence of the cavum septi pellucidi or widening of the inter hemispheric fissure, or associated extracranial findings. The sensitivity of screening exams is, however, unknown, but is probably limited.

CT/ MRI OF CC: The usual morphological MRI sequences include a sagittal T1 or T2 (fluid attenuated inversion recovery ((FLAIR)) weighted plane, as well as DTI reformatting images for an optimal study of the CC, were implemented. 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 T1 weighted imaging (WI) and a low signal in T2 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. Complete assessment of CC pathologies is facilitated by the acquisition of the following sequences: T1 WI, fast spin-echo (FSE) T2 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 organisation 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. 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-flight (TOF)) sequences, on the other hand, are essential in cases of ischaemic or hemorrhagic lesions. Images after contrast media enhancement are not necessary for the study of malformations or traumatic pathologies of the CC. 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, haemorrhage or infarction; CT angiography is essential for the diagnosis of aneurysms responsible for

haematomas, more commonly situated in the anterior part of the CC.

In recent years, several studies on MRI scans have been carried out to determine the diameters, morphology and sex-related differences of CC in various parts of the world. Takeda et.al [1] studied in 2003 using MRI on the Japanese showed that the length and height of CC was 69.7 and 25.9 mm, respectively in males and 69.4 and 25.8, respectively in female. He concluded that there is no difference in callosal measure between the two genders. Suganthy et.al [2] performed a study in India which was performed on 100 subjects using MRI; the length of CC in males was significantly higher than females (72.6 ± 5.2 mm in male, 70.6 ± 4.0 mm in female). Suganthy also reported that only the length of CC increased with the increase of age. Gupta et.al [3] studied on the Indian population in 2009, their MRI showed that the length and width of CC was 7.57 cm and 3.27 cm, respectively in men and 7.1 cm and 2.59 cm, respectively in women and the splenial width values were 1.15 cm in men and 1.17 cm in women. Furthermore, Gupta reported that the length and widths of CC in the Indian population were greater than the Japanese, but lower than the Caucasian population.

Karakas P et.al performed a research on size measurement of corpus callosum and ventricle. The mid sagittal images were used for measurements of the sub regions of corpus callosum and axial images were for lateral and third ventricles. Performer found that the mean values of the widths of genu, body, splenium, and height of the corpus callosum were 13.28, 7.64, 12.52, and 25.47 mm, respectively in females; whereas, the same measurements were 13.23, 6.89, 11.90, and 25.03 mm, respectively in males. Moreover, the mean value for the longitudinal dimension of the brain was 150.12 mm, while that for the corpus callosum was 71.27 mm in females. Additionally, the mean frontal horn width of the lateral ventricle and the transverse inner diameter of the skull were 34.06 and 130.76 mm in female and 34.03 and 129.96 mm in males, respectively. Due to these measurements, the values Evans index which are

reflecting the lateral ventricle enlargement were estimated to be 0.25 and 0.25 in females and males, respectively. According to their last measurement result, the mean values for the third ventricle width were 3.790 and 4.12 mm in females and males respectively. Mourgila et.al [5] reported that minimal variability in the dimensions and relative dimensions of the CC in Greek people. They also found that the longitudinal dimension of the genu and total CC were larger in males. Bermudez and Zatorre [4] studied on young normal volunteers and reported that male subject shows significantly larger absolute total areas as the anterior third and posterior mid-body of CC. However, total area of the anterior mid-body and splenium in female were bigger than males. Moreover, a strong difference in size, shape and position of CC among gender were found. Mohammad et al. [19] performed a research on size measurement of CC and found that mean value of longitudinal dimension of CC was 7.06 cm in North of Iran.

METHODOLOGY

Quantitative study is done with Cross sectional study design at Department of Radiology and Imaging, Tribhuvan University Teaching Hospital.

Materials used:

Hitachi Airis Vento MR system(0.3T)

T1 weighted sagittal spin-echo images with slice thickness 6 mm

SPSS version 20 and Microsoft Excel for statistical analysis

Sampling size and technique:

4 months of sample collection of MRI of Brain images, non-random purposive sampling

$$n = n Z\alpha^2 pq/d^2$$

Where, n = number of samples

p = proportion or prevalence=0.4

q = 1 – p =0.6

d = margin of error (the precision)=10% and

$$Z\alpha^2=1.96$$

$$(1.96)^2 \times 0.4 \times 0.6 / (0.1)^2 = 92.198 \approx 92$$

Data collection tool: Proforma was made to calculate the AP length and thickness of CC

Data collection method: Patients were informed about the procedure and after their informed written consent, they were asked to wear hospital dress. All MR images were acquired on 0.3T Airis Vento Hitachi system. T1 weighted sagittal spin-echo images with slice thickness of 6 mm were planned from an axial and coronal images to measure the corpus callosum length and thickness of Genu, Body and Splenium. The TR selected was 364 ms and TE selected was 15 ms, matrix size 256*256 according to department’s protocol. The measurements were carried out with the measuring tools available on the software of the system.

Inclusion criteria: Patients having normal findings in MRI of Brain

Exclusion criteria: Uncooperative patient, Patient having history of intracranial lesions, mass and stroke, Non Nepalese patient, Image having artifacts

Ethical consideration: Approval was taken from Institutional Review Board of the data collecting hospital, Informed consent was taken from the participant.

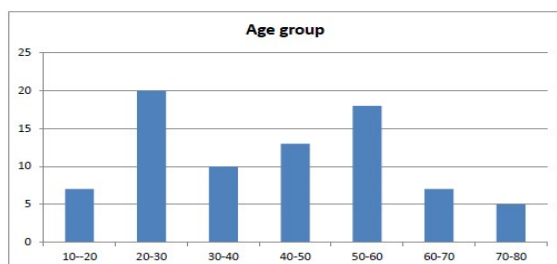
Data analysis: Statistical analysis was carried out with the help of SPSS version 20 and Microsoft Excel. Factor and percentages were calculated. Graphical representations were done through line diagrams.

RESULTS

The sample population consisted of 80 individual. The samples were taken in different ages and both male and female patients were included. Out of 80 patients the age wise distribution can be made as follows:

Figure 1: Age wise distribution

Age group



Out of 80 patients there were 39 female patients and 41 with male. Gender wise distribution is as shown follows:

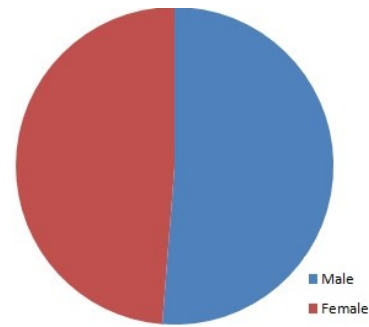


Figure 2: Gender wise distribution

The study showed that mean length of Corpus Callosum in Study Population to be 68.06 mm

Table 1: Length of CC

N	80
Mean	60.061
Std. Deviation	5.3411
Minimum	51.2
Maximum	79.6

Similarly, the study showed CC length in male to be 68.66 and in female 67.42 mm.

Table 2: Mean CC length in male and female.

Sex	Mean	N	Standard Deviation
F	67.427	39	5.1763
M	68.427	41	5.4885
Total	68.061	80	5.3411

The mean length of CC were measured in different age groups and tabulated as

Table 3: Mean CC length in different age groups.

Age group	Mean	N	Standard Deviation
10-20	60.449	9	5.0832
20-30	66.965	20	4.6299
30-40	70.41	10	2.4556
40-50	70.092	12	5.6992
50-60	68.612	17	4.4601
60-70	69.586	7	8.2959
70-80	68.96	5	3.8501
80-90	68.061	80	5.3411

Similarly, the study resulted in mean thickness of Genu, body and splenium is 9.1, 5.2 and 9.08 mm respectively and mean thickness of CC is 7.81mm

Table 4: Mean thickness of different Parts of CC.

	Thickness			Mean
	Genu	Body	Splenium	
Mean	9.157	5.201	9.08	7.8133
Std. Devⁿ	1.6671	1.093	1.5578	1.1395

The mean thickness of different parts of CC in female and male were tabulated as:

Table 5: Mean thickness of different parts of CC in male and female.

Sex	Thickness			
	Genu	Body	Splenium	Mean
F	9.115	5.154	9.041	7.7701
M	9.198	5.246	9.118	7.8545
Mean	9.157	5.201	9.081	7.8133

The mean thicknesses of different parts of CC in different age groups were tabulated as:

Table 6: Mean thickness of different parts of CC in different age groups.

Age groups	Thickness			
	Genu	Body	Splenium	Mean
10-20	9.12	5.2	8.77	7.7
20-30	9.35	5.52	9.22	8.03
30-40	10.77	5.46	10.1	8.77
40-50	8.45	5.28	9.05	7.6
50-60	9.24	5.05	9.14	7.81
60-70	7.67	4.55	8.92	7.05
70-80	8.68	4.6	7.08	6.78
Total	9.15	5.2	9.08	7.81

The upper value in each cell is the Pearson correlation Coefficient between corresponding row and column variables. The lower value is P-value. (Table-7).

Table 7: t-Value and p-Value of CC in Male and Female.

Variable	Sex	N	Mean	Std Dev	t Value	p-Value
Length of CC	F	19	67.1421	5.1969	-0.76	0.4506
	M	19	68.5263	5.9642		
Thickness of Genu	F	19	8.9947	2.0384	-0.04	0.9684
	M	19	9.0211	2.0297		
Thickness of Body	F	19	4.8526	0.8475	-0.69	0.4925
	M	19	5.0895	1.2242		
Age	F	19	38.1579	20.0673	-1.01	0.3184
	M	19	44.5789	19.0447		

Table 8: Pearson Correlation Coefficients of CC.

Pearson Correlation Coefficients, N=38 Prob> r underH0:Rho=0				
	Length of CC	Thickness of Genu	Thickness of Body	Age
Length of CC		-0.16578 0.3199	0.05688 0.7345	0.48829 0.0019
Thickness of Genu	-0.16578 0.3199		0.56538 0.0002	-0.37978 0.0187
Thickness of Body	0.05688 0.7345	0.56538 0.0002		-0.2625 0.1114
Age	0.48829 0.0019	-0.37978 0.0187	-0.2625 0.1114	

It also showed that mean length of CC was 67.427 mm with SD 5.1763 in female and 68.663mm with SD 5.4885 in male.

Mean length of CC was varied with age group. It was found that highest length of CC is in 30-40 age groups and not increases with age from this group. The populations of age group

The last cell of the second column, the Pearson correlation Coefficient is 0.48829 between Age and Length of CC, its P-value is 0.0019. (Table-8)

DISCUSSION

In this study, Sagittal Section of MRI head of 80 patients were analyzed for the size of Corpus Callosum and it was found to be largest length of CC among the age group from 20-30 years and smallest among the age groups from 70-80 years

Our study found that the mean length of CC was 68.061 mm with SD 5.3411, near to Takeda et.al [1] study on Japanese population in which average length was 69.7 in male and 69.4 in female. In my project work I used T1 SE sagittal sequences of head. The difference on result with previous studies and my project work is because of higher magnetic field that provides better soft tissue resolution, higher spatial and contrast resolution and easy to take measurement more accurately that was use by other studied.

10-20 have 62.449mm length with SD 5.0832. Similarly in 20-30 age group have 66.965 length with SD 4.6299. In 30-40 age group mean length was found to be 70.410mm with SD 2.4556. In 40-50 age group mean length was found to be 70.092 mm with SD 5.6992. In 50-60 age group mean length was found to be 68.612mm with

SD 4.4601. In 60-70 age group mean length was found to be 69.586mm with SD 8.2959. In age group 70-80 mean length was found to be 68.960mm with SD 3.8501.

Thickness of different parts of CC was also studied in this project work. It was found that mean thickness of genu was 9.157 mm with SD 1.6671, body was 5.201mm with SD 5.201 and splenium was 9.081mm with SD 1.5578. The average thickness of CC was 7.81

Karakas P. et al. performed a research on size measurement of corpus callosum. Performer found that the mean values of the widths of genu, body, splenium were 13.28, 7.64, 12.52 respectively in females; whereas, the same measurements were 13.23, 6.89, 11.90, and 25.03 mm, respectively in males. In our study variation in the mean thickness of different parts of CC was also found in male and female. It was found that genu, body and splenium thickness was 9.198, 5.246 and 9.118mm in male respectively. In female it was 9.115, 5.154 and 9.041 mm respectively

CONCLUSION

The mean length of Corpus Callosum is 68.06 mm with S.D 5.34 in this study. The mean thickness of Genu is 9.15 mm with S.D 1.66, body is 5.2 mm with S.D 1.09 and splenium is 9.08 mm with S.D 1.55. The average thickness of CC is 7.81 mm. The project work showed variation in the mean length and thickness of Corpus Callosum on different age and sex.

Conflicts of Interests: None

REFERENCES

- [1]. Takeda S, Hirashima Y, Ikeda H, Yamamoto H, Sugino M, Endo S. Determination of indices of the corpus callosum associated with normal aging in Japanese individuals. *Neuroradiology*. 2003;45(8):513-8.
- [2]. 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(5):396-403. doi: 10.1002/ca.10161.
- [3]. 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.
- [4]. Bermudez P, Zatorre RJ. Sexual dimorphism in the corpus callosum: methodological considerations in MRI morphometry. *Neuroimage*. 2001;13(6 Pt 1):1121-30. doi: 10.1006/nimg.2001.0772.
- [5]. Mourgela S, Anagnostopoulou S, Sakellaropoulos A, Gouliamos A. An MRI study of sex- and age- related differences in the dimensions of the corpus callosum and brain. *Neuroanatomy*. 2007;6(1):63-5.
- [6]. Yamauchi H, Fukuyama H, Shio H. Corpus callosum atrophy in patients with leukoaraiosis may indicate global cognitive impairment. *Stroke*. 2000; 31(7):1515-20. doi: 10.1161/01.STR.31.7.1515.
- [7]. Tomaiuolo F, Di Paola M, Caravale B, Vicari S, Petrides M, Caltagirone C. Morphology and morphometry of the corpus callosum in Williams syndrome: a T1-weighted MRI study. *Neuroreport*. 2002;13(17):2281-4. doi: 10.1097/00001756-200212030-00022.
- [8]. von Plessen K, Lundervold A, Duta N, Heiervang E, Klauschen F, Smievoll AI, et al. Less developed corpus callosum in dyslexic subjects— a structural MRI study. *Neuropsychologia*. 2002;40(7):1035-44 doi: 10.1016/S0028-3932(01)00143-9.
- [9]. Plessen KJ, Wentzel-Larsen T, Hugdahl K, Feineigle P, Klein J, Staib LH, et al. Altered interhemispheric connectivity in individuals with Tourette's disorder. *Am J Psychiatry*. 2004;161(11):2028-37. doi: 10.1176/appi.ajp.161.11.2028.
- [10]. Teipel SJ, Schapiro MB, Alexander GE, Krasuski JS, Horwitz B, Hoehne C, et al. Relation of corpus callosum and hippocampal size to age in nondemented adults with Down's syndrome. *Am J Psychiatry*. 2003;160(10):1870-8. doi: 10.1176/appi.ajp.160.10.1870.
- [11]. Lacerda AL, Brambilla P, Sassi RB, Nicoletti MA, Mallinger AG, Frank E, et al. Anatomical MRI study of corpus callosum in unipolar depression. *J Psychiatr Res*. 2005;39(4):347-54. doi: 10.1016/j.jpsychires.2004.10.004.
- [12]. Narr KL, Cannon TD, Woods RP, Thompson PM, Kim S, Asuncion D, et al. Genetic contributions to altered callosal morphology in schizophrenia. *J Neurosci*. 2002;22(9):3720-9.
- [13]. Thompson PM, Dutton RA, Hayashi KM, Lu A, Lee SE, Lee JY, et al. 3D mapping of ventricular and corpus callosum abnormalities in HIV/AIDS. *Neuroimage*. 2006;31(1):12-23. doi: 10.1016/j.neuroimage.2005.11.043.
- [14]. Peterson BS, Feineigle PA, Staib LH, Gore JC. Automated measurement of latent morphological features in the human corpus callosum. *Hum Brain Mapp*. 2001;12(4):232-45. doi: 10.1002/1097-0193(200104)12:4<232::AID-HBM1018>3.3.CO;2-A.
- [15]. Luders E, Narr KL, Zaidel E, Thompson PM, Toga AW. Gender effects on callosal thickness in scaled and unscaled space. *Neuroreport*. 2006; 17(11):1103-6. doi: 10.1097/01.wnr.0000227987.77304.cc.
- [16]. 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 MRI study of elderly men. *Cereb Cortex*. 2002;12(4):438-45. doi: 10.1093/cercor/12.4.438.

- [17]. Luders E, Rex DE, Narr KL, Woods RP, Jancke L, Thompson PM, et al. Relationships between sulcal asymmetries and corpus callosum size: gender and handedness effects. *Cereb Cortex*. 2003;13(10):1084–93. doi: 10.1093/cercor/13.10.1084.
- [18]. Estruch R, Nicolas JM, Salamero M, Aragon C, Sacanella E, Fernandez-Sola J, et al. Atrophy of the corpus callosum in chronic alcoholism. *J Neurol Sci*. 1997;146(2):145–51. doi: 10.1016/S0022-510X(96)00298-5.
- [19]. Mohammadi MR, Zhand P, Mortazavi Moghadam B, Golalipour MJ. Measurement of the corpus callosum using magnetic resonance imaging in the north of iran. *Iran J Radiol*. 2011 Dec;8(4):218-23. doi: 10.5812/iranradiol.4495. Epub 2011 Dec 25. PMID: 23329944; PMCID: PMC3522367.

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