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Anatomo-Radiological Study of the Corpus Callosum and its Morphometry of Nigerians Residing in Port-Harcourt Using Magnetic Resonance Imaging (MRI)

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Abstract

The Corpus callosum's morphometric assessment is crucial for identifying several normative dimensions that may be applied as a diagnostic tool. The purpose of this study is to ascertain whether the size, age, and shape of the corpus Callosum of residents in Port-Harcourt, Nigeria, differ according to sex or ethnicity. The study used 204 MRI scans of healthy brains that had been archived, and it combined a cross-sectional study design with a qualitative research methodology. The minimal sample size was established using the Cochran formula. Radiologic measuring software (DICOM) was used to collect the data, and SPSS version 23 T-test was used for analysis. The mean results for males were as follows: T(Genu) 12.020 ± 1.427 cm, T(Body) 6.770 ± 0.824 cm, T(Splenium) 12.320 ± 1.387 cm, DOG 34.752 ± 3.871 cm, DOS 50.750 ± 5.937 cm, and Max L 80.145 ± 4.670 cm, Max H 23.305 ± 4.121 cm, and CCI 0.3946 ± 0.0394. The mean values for females were as follows: T(Genu) 11.846 ± 1.370 cm, T(Body) 6.790 ± 0.685 cm, T(Splenium) 12.175 ± 1.247 cm, DOG 32.615 ± 3.277 cm, DOS 49.580 ± 6.302 cm, and MaxL 75.850 ± 4.086 cm, Max H 22.950 ± 2.380 cm, and CCI 0.4149 ± 0.0518. Males are larger than females, according to the morphometry of the corpus callosum across these parameters; the Max L, DOG, DOS, and CCI showed statistical differences at ($P<0.05$), while the others showed no statistical differences at ($P>0.05$). Anatomists, radiologists, and neurosurgeons will find this study useful.

Keywords; Corpus Callosum, Magnetic Resonance Imaging (MRI), and Port Harcourt

Introduction

The corpus callosum, the main commissural area of the brain that includes the white matter tracts connecting the left and right cerebral hemispheres, is composed of approximately 200 million heavy myelinated nerve fibers that form homotopic or heterotrophic projections to contralateral neurons in the same anatomical layer. According to Andrea et al. (2017), the corpus callosum grows quickly during infancy as a result of an increase in myelin, axon diameter, and axon number. Despite being fully developed by the age of four, growth continues at a much slower rate until the third decade of life. Histological findings indicate that the corpus callosum is made up of four parts, which are arranged anatomically from anterior to posterior: the rostrum, the thicker beaked segment, and the thinner lamina rostralis (continuous with the lamina terminals).

According to, [8] Alzheimer's disease has been linked to callosal changes caused by brain atrophy. While medial temporal atrophy is a characteristic of Alzheimer's disease, the corpus callosum, which is a structure made entirely of white matter tract, would reflect the white matter changes seen in Alzheimer's disease. [10] Abnormalities in callosal morphology have also been reported in neuropsychiatric diseases such as depression, schizophrenia, and bipolar disorder. Corpus callosum lipomas are classified as either curvilinear, which are typically found posteriorly and are asymptomatic, or tubulonodular, which are found anteriorly and are associated with severe frontal abnormalities [3b]. Atherosclerotic plaques or vasospasm of the supplying arteries can cause stenosis, and emboli can cause ischemia due to emboli, even though ischemia of the corpus callosum is uncommon because of vascular inputs from the three main arteries: the anterior communicating, anterior pericallosal, and posterior cerebral arteries [5]. Hemorrhages of the corpus callosum are usually caused by ruptured aneurysms in the anterior cerebral or pericallosal arteries. The corpus callosum has also been linked to a wide range of other pathologies, including the following: Marchiava-Bignami disease, which results in acute demyelination and necrosis of the corpus callosum, is most frequently observed in the corpus callosum body region in patients with chronic alcoholism; other toxins, like carbon monoxide, and drugs, like cocaine and heroin, have also been linked to demyelination and lesions in the corpus callosum; other pathologies that can cause demyelination and lesions in the corpus callosum include exposure to specific viruses, metabolic dysfunction, and traumatic brain injury; the most frequent tumors in the corpus callosum are glioblastomas, as well as lymphomas and metastases. Although the corpus callosum may be infected, the symptoms of a corpus callosum stroke are nonspecific and ambiguous. The corpus callosum has been the most extensively researched structure in patients with autism spectrum disorder (ASD). This is because it is hypothesized that patients with ASD have smaller corpus callosums and that poor brain connectivity in autism may be reflected anatomically in the white matter structure that connects the two hemispheres. In decreasing order, these are the most typical corpus callosum stroke symptoms and indicators: In patients who can cooperate with physical examination, there are different levels of limb dyskinesia (84%), language disorder, including some degree of mixed aphasia, complete motor aphasia, incomplete motor aphasia, or unclear words or clumsy speech (48%), cognitive or mental abnormality (40%), grope for action and forced laughter and crying (20%), partial body hypoalgesia (8%), incontinence (8%), alien hand syndrome (4%), and visual field loss (4%). According to [12], callosal alterations take place during human growth and age, with morphology reflecting hemisphere asymmetries and gender disparities. Boundary-based callosal segmentation [6] is a useful automated method for accurately segmenting, aligning, and measuring the corpus callosum. These algorithms typically require a training set of hand-segmented callosa to define a population-specific atlas of callosal templates, which can either be used to define a shape or appearance model of the callosum or warped upon T1 callosal images to try and match new callosa. The advantage of boundary-based methods using atlases is that they perform better when it comes to automatically segmenting the callosum from the fornix and pericallosal artery because the atlas or its derived shape models can strongly constrain permissible callosal shapes. In this study, we present a brand-new, totally automated rule-based method that eliminates the need for manual callosal segmentation. Prior research on corpus callosum measurements was conducted on autopsy specimens; however, after mortem alterations brought on by fixation agents and shrinkage impact observed dimensions.

The gold standard for morphomeric studies of the corpus callosum has been the use of high resolution magnetic resonance imaging (MRI), which provides good spatial representation and excellent soft tissue differentiation. In corpus callosum studies, contrast agents are not necessary, and there is no chance of ionizing radiation exposure.

Variations in the morphology and morphometery of the corpus callosum can be indicative of pathological conditions such as, agenesis, hypoplasia, dysgenesis and Neurodegenerative Diseases (Parkinson's, Alzheimer's and Huntington's disease). Despite their importance, there is limited neurological data on these variations in different populations especially Nigerians, residing in Port Harcourt. This gap in knowledge can lead to challenges in accurate diagnosis.The morphology and morphometery of the corpus callosum is subjected to individual variations and these variations can have significant clinical implications. Despite their clinical significance, there is lack of comprehensive radiological data on these variations across different populations. The need for systematic radiological studies to map out these variations, establish normal data, and identify correlations with sex, age, and ethnicity is the driving force behind this research because a lack of detailed knowledge can impede accurate diagnosis and result in misdiagnosis of conditions that could otherwise be detected with proper radiological reference values.

Aim

The purpose of this study is to ascertain whether the size, age, and shape of the corpus callosum differ according to gender or ethnicity.

Study Design

In partnership with the Department of Radiology at the University of Port Harcourt Teaching Hospital (UPTH), a student in the Human Anatomy department will conduct this cross-sectional observational study for a period of one month.

Population study

The population study consist of Magnetic Resonance imaging (MRI) scans (described as radiological normal) belonging to 204 people both male and female of the University of Port Harcourt Teaching Hospital(UPTH) who referred to the Department of Radiology for MRI of the brain.

Material and Method of data collection

The study's data is gathered by retrieving the archived MRI brain scan results of patients. Radiologic measurement software (DICOM) will be used to gather data based on a number of corpus callosum parameters determined by mid-saggital MRI scans, such as:

Maximum length lmax (in millimeters): The separation between the genital and splenic anterior and posterior edges.

hmax, the maximum height (in mm): a line that runs from the tip of the rostrum to the superior border of the corpus callosum.

To calculate the forebrain diameter, the fronto-occipital diameter of the corpus callosum was measured from the most anterior (frontal lobe) to the most posterior (occipital lobe) points of the corpus callosum.

The thickness of the corpus callosum is determined by measuring the height of the body in millimeters and the breadth of the genu and splenum in millimeters.

Inclusion Criteria

Patients with no neurological signs, no intracranial lesions, mass or head injury on MRI, all scan are to be radiologically normal.

Exclusion criteria

Exclusion criteria comprises the presence or documentation of any pathological process distorting the anatomy of the corpus callosum

Data Analysis

In order to perform descriptive statistics and compare mean values and standard deviation utilizing basic frequency tables, charts, means, and percentages, the collected data will be examined using SPSS Version 23 statistical software.

RESULTS

Table 1: Demographic profile of study of the population

S No.	Gender	No. of Subjects	Percentage
1	Males	68	33.3
2	Females	136	66.7

Table 1, Shows the demographic profile of the Sample size with percentage

Table2: Mean values of the individuals with respect to gender differences

S/N	Gender(N)	Min.	Max.	Median	Mean	SD	95% LB	95% UB
1	Age (yrs)							
	Male	18	80	41.50	45.56	18.14	41.169	49.949
	Female	18	88	42.50	45.81	17.66	42.814	48.804
	Total(204)	18	88	42.50	45.73	17.78	43.271	48.179
	T=0.09, p= 0.926							
2	MAX L(mm)							
	Male	70.520	92.100	80.145	79.317	4.670	78.186	80.447
	Female	66.21	88.580	75.850	75.766	4.086	75.073	77.584
	Total(204)	66.21	92.100	76.470	76.949	4.595	76.315	77.584
	T=-5.33, p= 0.000							
3	MAX H(mm)							
	Male(68)	1.210	33.820	23.305	23.314	4.121	22.316	24.311
	Female(136)	17.62	29.89	22.95	23.204	2.38	22.800	23.608
	Total(204)	1.210	33.820	22.975	23.240	3.063	22.818	23.663
	T=-0.20, p= 0.839							
4	DOG(mm)							
	Male(68)	28.490	53.760	34.752	34.944	3.871	34.007	35.881
	Female(136)	23.36	42.19	32.615	32.843	3.277	32.220	33.722
	Total(204)	23.36	53.760	33.380	33.543	3.615	33.044	34.042
	T=-3.84, p= 0.000							

5	Dos (mm)							
	Male(68)	38.870	68.130	50.750	51.551	5.937	50.113	52.988
	Female(136)	13.88	63.08	49.58	49.661	6.302	48.592	50.730
	Total(204)	13.88	68.130	50.075	50.291	6.232	49.431	51.151
	T=-2.10, p= 0.038							
6	T(GENU)(mm)							
	Male(68)	9.000	15.00	12.020	11.779	1.427	11.434	12.125
	Female(136)	6.63	14.56	11.86	11.846	1.370	11.614	12.079
	Total(204)	6.63	15.00	12.000	11.824	1.386	11.633	12.015
	T=0.32, p= 0.749							
7	T(BODY) (mm)							
	Male(68)	5.250	9.00	6.770	6.8494	0.824	6.6450	7.0388
	Female(136)	5.25	8.39	6.790	6.836	0.685	6.7290	6.9623
	Total(204)	5.250	9.00	6.7900	6.844	0.7326	6.7422	6.9449
	T=0.05, p= 0.957							
8	T(SPLENIUM)(mm)							
	Male(68)	9.110	17.320	12.320	12.590	1.387	12.254	12.925
	Female(136)	9.78	16.52	12.175	12.419	1.247	12.207	12.630
	Total(204)	9.110	17.320	12.300	12.476	1.295	12.297	12.655
	T=-0.86, p= 0.394							
9	Corpus Callosum Index (CI)							
	Male(68)	0.2835	0.5001	0.3946	0.3943	0.0394	0.3847	0.4038
	Female(136)	0.0404	0.5243	0.4149	0.4092	0.0518	0.4004	0.4179
	Total(204)	0.2835	0.5243	0.4079	0.4063	0.0409	0.4007	0.4300
	T=2.28, p= 0.024							

Keyword from Table 2: Max L: Maximum Length of CC; Max H: Maximum Height of CC; DOG: Distance from Genu to frontal lobe of CC; DOS: Distance from Splenium to Occipital lobe; T(Genu): Thickness of Genu of CC; T(Body): Thickness of Body of CC; T(splenium) : Thickness of Splenium of CC; CCI: Corpus callosum index

The maximum mean length was 7.69+0.46 cm, the maximum mean height was 2.32+0.31 cm, the mean distance from the frontal lobe (DOG) was 3.34+0.36 cm, the mean distance from the occipital pole (DOS) was 5.03+0.62 cm, the mean thickness of Genu was 1.18+0.14 cm, the mean thickness of the body was 0.68+0.073 cm, the mean thickness of Splenium was 1.25+0.13 cm, and the mean CCI calculation indicates 0.041+0.0041 cm. With the exception of the mean thickness of Genu (male 1.17+0.14cm; female 1.18+0.13cm), all measurements were shown to be higher in males than in females. Gender differences were found in most corpus callosum dimensions at ($P>0.05$) according to statistical analysis. The distance from the frontal lobe (DOG) and maximum length, however, did not differ significantly ($P < 0.000$).

Table 3: Correlation Test of the Relationship between Age and Corpus Callosum Dimension

Dimension	Frequency	Pearson correlation	P-value
MAX L(mm)	204	0.315	0.000
MAX H(mm)	204	0.336	0.000
DOG(mm)	204	-0.359	0.000
DOS(mm)	204	-0.146	0.037
T(GENU) (mm)	204	-0.391	0.000
T(BODY) (mm)	204	-0.440	0.000
T(SPLENIUM) (mm)	204	0.330	0.000
Corpus Callosum Index	204	-0.606	0.000

Table 3: A statistically significant but weakly positive correlation between age and the CC's length, height, and splenium dimensions was found using Pearson's correlation analysis. In contrast, the genu, body, and CCI dimensions, as well as the distance from the frontal lobe (DOG) and the distance from the occipital lobe (DOS), were all weakly negatively correlated and did not exhibit any statistical significance, with the exception of DOS.

Table 4: Variations of the Dimensions of the Corpus Callosum across different Age Groups

Dimension Of age group	18-27, n=30 Mean ±SD	28-37 N=53 Mean ±SD	38-47 N=35 Mean± SD	48-57 N=29 Mean ±SD	58-67 N=24 Mean ±SD	68-77 N=27 Mean ±SD	78+ N=6 Mean ±SD
MAX L	75.10±5.75	75.10±4.12	76.05±4.3	78.33±4.54	77.21±4.53	79.84±2.87	78.26±1.82
MAX H	22.55±2.11	21.90±3.43	22.83±2.85	23.38±2.40	25.44±3.20	24.64±2.64	24.94±1.69
DOG	36.41±3.01	33.49±2.80	34.23±4.83	32.84±2.85	32.45±3.13	32.22±3.38	29.48±1.95
DOS	52.14±6.29	51.39±4.97	48.72±8.41	49.11±5.73	53.11±4.60	48.52±5.62	47.32±7.77
T(GENU)	12.21±1.36	12.33±4.97	12.10±1.32	12.01±1.33	10.95±1.57	10.94±1.08	10.52±0.95
T(BODY)	7.16±0.62	7.71±0.64	6.97±0.61	6.99±0.69	6.45±0.71	6.23±0.68	6.23±0.71
T(SPLENIUM)	12.75±1.10	12.87±1.10	12.46±1.10	12.88±1.62	12.01±1.22	11.69±1.28	11.21±1.4

Analysis of variance is used to compare the means of corpus callosum dimensions across age groups in Table 4. As the CC ages, its height and length greatly grow. On the other hand, as people aged, their dog, dos, genu, body, and splenial dimensions decreased.

Table 5: Shows the Comparison of the Corpus Callosum Across the Different Populations from the Previous work.

Studies/Country	Number Of Respondents	Mean/Median Age	Cc Length (Mm)	Cc Height (Mm)	Genu (Mm)	Body (Mm)	Splenium (Mm)
Allouh et al 2020 (Jordan)	100		68.45±4.1	-	10.85±1.4	6.15±0.8	16.65±2.4
Arda et al to 2019 (Turkey)	436	47.05±19.8	68.0±4.9	24.7±3.1	10.7±1.8	5.81±1.1	13.6±0.9
Takeda et al 2003 (Japan)	205	59.25±19.2	69.7±4.2	25.8±2.8		5.58±1.	9.94±1.6
Junle et al 2008 (China)	286		70.74±4.4	24.59±2.7	11.68±1.4	6.33±0.9	11.53±1.3
Krishna et al 2020 (India)	420		69.59±5.6		10.47±1.8	5.36±0.98	10.03±1.6
Ajare et al 2023 (South east Nigeria	200	43.57±19.0	75.94±4.9	24.77±4.0	10.88±1.9	5.64±1.4	11.01±1.7
Present Study (Port-Harcourt Nigeria)	204	45.73±17.78	76.95±4.9	23.24±3.06	11.82±1.38	6.84±0.73	12.47±1.29

DISCUSSION

Since the corpus callosum (CC), the largest inter-hemispheric white matter tract in the human brain, varies in shape among people of different racial and gender identities, it has long been the focus of extensive research and debate, especially in relation to the relationship between its morphology and various facets of neurological function. The CC is structurally separated into the rostrum, genu, body, and splenium from rostral to caudal. In order to help with future diagnostic and disease-related research, as well as potential applications in forensic medicine, we examined these variations in our study and produced normative anatomical reference data. The average CC length in our sample was 76.95 mm, and it was statistically significant (p=0.000) that males had longer CCs than girls. However, our investigation revealed that, with the exception of the mean thickness of Genu (male 1.17+0.14cm; female 1.18+0.13cm), all measurements were higher in males than in females. Additionally, we found that the CC's height and length in our sample positively correlate with age and rise significantly. As age advances, we also noticed changes in the size of the different CC components. The genital and splenic diameters grew until middle age and then began to gradually decrease with age, a trend that is statistically significant. To summarize our findings, we listed them as follows:

1. The Maximum Length of CC: showed a statistically significant variation in dimension between males and females.
2. There was no discernible difference in the maximum height of CC between males and females, but it was slightly higher in the former.
3. There were statistically significant differences in the distance between the Genu and the frontal lobe between males and females, demonstrating that men's forebrains were larger than women's.

4. Males had a longer distance from the splenium to the occipital lobe than females, however there was no statistically significant difference.
5. There was no statistically significant difference in the thickness of Genu, which was found to be slightly bigger in females than in males.
6. Males were found to have a little higher body thickness than females; however there was no statistically significant difference.
7. Splenium thickness was found to be somewhat higher in males than in females, however there was no statistically significant difference.
8. Males had a higher corpus callosum index than females, although there was no statistically significant difference.

9. We found that the CC's height and length in our group positively correlate with age and rise noticeably with age.
10. Was noticed that the diameter of the genu and splenium increased until middle age and afterward declined they had a tendency of diminishing progressively with aging.

CONCLUSION

This study assessed how respondents' morphometric Corpus Callosum dimensions varied by age and gender across populations in Port-Harcourt, Nigeria. The results indicate that the mean length of the corpus callosum varies significantly by gender. While the genu and splenium grow until middle age and then begin to decline, the CC's height and length greatly expand with age. Furthermore, there was no correlation between age and the rostrum and body dimensions. The following is provided in order to help with this:

1. The study offers a thorough examination of the many corpus callosum components, including structures like the genu, body, and splenium. This adds accurate measurements to anatomical databases that can be used in clinical settings to help diagnose and treat neurological conditions like Alzheimer's disease.
2. The study revealed that the dimensions of the corpus callosum varied by gender, with men displaying larger dimensions than women. In disciplines including radiography, neurosurgery, and forensic anthropology, this realization has practical applications.
3. The study demonstrates how many ethnic groups differ morphologically. It is essential to take into account the possible variations in confounding variables, such as genetic and environmental influences.
4. The study demonstrated several techniques, including MRI, for assessing corpus callosum morphology. Research questions are appropriate for this methodological technique.
5. The results aid in radiological interpretation and surgical planning by offering reference values for corpus callosum diameters, which are essential for brain-related treatments.

6. The study establishes the foundation for future research on the clinical and evolutionary features of corpus callosum, which could impact our comprehension of neurological disorders and individual differences.

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