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The dimensions of the corpus callosum of the cerebrum-An anatomical study

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RESEARCH

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ABSTRACT

Aims
To determine the dimensions of the human corpus callosum and its parts. The objective was also to know its location in the cerebral hemisphere of South Indians.

Methods
Twenty mid-sagittal sections from formalin fixed human cadaveric brain specimens were used for this study and the parameters recorded were: distances from frontal pole to occipital pole (AB), inferior surface to the superior surface of the brain (CD), frontal pole of brain to genu (AG), occipital pole of cerebrum to corpus callosum splenium (BS), from splenium of corpus callosum to superior colliculus (Ls-SC) and inferior colliculus (Ls-IC), genu to fornix (GF), outer curvature O (G-S) and inner curvature I (G-S) from genu to splenium, the entire outer curvature (OUTCR) and inner curvature (INCUR) from beginning of corpus callosum rostrum to the splenium end. We did also measure the thicknesses of its splenium (S), isthmus (I), body (T), genu (G) and rostrum (R).

Results
Statistical analysis using correlation study showed significance between A-B and B-S, O (G-S) and INCUR, O (G-S) and OUTCR, A-G and R, T and I. Highly significant correlations were found between C-D and Ls-IC, O (G-S) and I (G-S), I (G-S) and G-F, G-F, and G. Very highly significant correlations were seen between I (G-S) and INCUR, Ls-SC, and Ls-IC, T and S.

Conclusion
This morphometric study on the corpus callosum provides data that could be valuable in the diagnosis of lesions of the corpus callosum. The data are of particular relevance to neurologists and radiologists.

Key Words
Cerebrum, corpus callosum, white matter

What this study adds:

1. What is known about this subject?
Dimensions of the corpus callosum are important in the diagnosis of lesions affecting it.

2. What new information is offered in this case study?
Morphometric data of the corpus callosum on subjects from the Southern part of India is provided in this study. This includes new information on its topography from the cerebral frontal pole to the cerebral occipital pole.

3. What are the implications for research, policy, or practice?

The data and correlations observed in the present study is of practical significance for neurologists, neurosurgeons and radiologists.

Background

The white matter of the cerebrum is made up of three types - association, commissural and projection of fibres. The largest among the commissural variety is the corpus callosum, which connects the two cerebral hemispheres. The corpus callosum is an arched structure 10cm in length, the anterior end of which is about 4cm from the frontal pole and the posterior end is about 6cm from the occipital pole of the cerebrum. Its anterior end, the genu re-curves postero-inferiorly and thins out to become the rostrum, which is at the cephalic part of the lamina terminalis. The corpus callosum body bends backward and expands to form the thickest part, the splenium.[1] The splenium, body, genu and rostrum are its parts as per the standard texts.[2] The abundant white matter fibres serve in the interaction between the two cerebral hemispheres. Behavioural changes in individual and cognitive sequelae depend on the exact location of fibre loss in the corpus callosum.[3] It has been described that the white matter fibres present are constant in quantity at the time of birth; but morphological changes in its structure occur throughout postnatal growth because of pruning, redirection, and myelination of fibers.[4]

The corpus callosum contains densely packed myelin fibres, hence only aggressive space occupying lesions like glioblastoma multiformis and lymphomas involve or may cross it.[5] Glioblastoma multiformis is the most common tumour and accounts for 25 per cent of all primary brain tumours. This tumour spreads along white matter tracts and displays a characteristic bihemispheric involvement which results in a classical butterfly shape.5 Glioblastoma mutiformis is considered as the brain tumour with the poorest prognosis. It has been reported that the shape and diameters of its region should be known before performing callosotomies in cases of intractable epilepsy.6 Morphometric data of the corpus callosum have clinical implications; however, this structure has been poorly studied in South Indians. The goal of the present investigation was to study the corpus callosal morphometry, and to gain precise knowledge of its location in the cerebral hemispheres of Southern Indians.

Method

Mid-sagittal sections (Figure 1) of 20 formalin fixed brains were included in the present study. The distribution of the sample according to the age and gender were not possible in the present investigation. Specimens which exhibited pathological changes were excluded. The dimensions recorded were: distances from frontal to occipital poles (AB), inferior surface to the superior surface of the brain (CD), frontal pole of brain to genu (AG), occipital pole of cerebrum to the posterior end of splenium (BS), from splenium to superior colliculus of midbrain (Ls-SC) and inferior colliculus (Ls-IC), genu to fornix (GF) (Figure 2). These measurements were performed by using a digital Vernier calliper. The outer curvature OUTCR) and inner curvature (INCUR) from the beginning of the rostrum to the end of the splenium O (G-S) and inner curvature I (G-S) from genu to splenium as well as the entire outer curvature were also measured (Figure 3). These curvatures were recorded with the help of points marked on a cotton thread and then recorded over a scale. We also measured thicknesses of the splenium (S), isthmus (I), body (T), Genu (G) and rostrum (R) (Figure 3) by using a digital Vernier calliper. The statistical analysis was performed using Karl Pearson's coefficient of correlation, where data with r>0.5 has significant relationship, $p<0.05$ is considered as statistically significant, $p<0.01$ is highly significant and $p<0.001$ is of very high significance.

Results

The morphometric data obtained in our investigation are shown in Table 1. The statistical significance and the correlation are given in Tables 2 and 3. The statistical analysis showed significance between A-B and B-S, O (G-S) and INCUR, O (G-S) and OUTCR, A-G and R, C-D and Ls-SC, T and I. It was observed that highly significant correlation was between C-D and Ls-IC, O (G-S) and I (G-S), I (G-S) and G-F, G-F, and G. Very highly significant correlation was seen between I (G-S) and INCUR, Ls-SC and Ls-IC, T and S.

Discussion

Development of the corpus callosum takes place at approximately 8–10 weeks of intrauterine life.[7] According to a radiological study by Kosar et al.,[8] except for the genu region, the corpus callosum grows significantly from childhood to adult and there was no gender-based variation. It has been described that the corpus callosum is topographically organized as per the reports of partial ablation, neuroanatomical and electrophysiological studies from nonhuman primates.[9] It has been reported that the particular connections and tracts are transferred through a specific part of the corpus callosum in humans.[10] Taste fibres are transferred through the rostral end of the corpus callosum and also the genu. Its body is involved in motor functions and touch. The visual pathway and the auditory pathway pass through the isthmus and splenium.[10] The different parts are proportionate to each other.[6] Detailed morphometric data of the corpus callosum are essential to neurosurgical and radiological practice. Consideration of the different parts of the corpus callosum enables a callosotomy to be performed easier. The morphometric data can also be of particular relevance and importance in conservative neurosurgery of the different parts of the corpus callosum.

There are only few studies reported about the morphometry of the corpus callosum and data are particularly scarce from the South Indian population. Our present study aimed to provide morphometric data from cadaveric brain samples. The mean distance between the anterior end of the corpus callosum and the frontal pole of the cerebrum (AG) was 3.32cm. The mean distance of the posterior end of the splenium to the occipital pole (BS) was 5.11cm. These findings are almost the same as previous observations made by Anagnostopolou et al.[6] and Mohammad et al.[11] We observed that the mean thickness of the genu (G) and splenium (S) were 1.1cm and 1.02cm, respectively. However, in the study conducted by Mohammad et al.,[11] it was 2.35cm and 1.41cm and by Anagnostopoulo et al.,[6] it was 2.46cm and 1.48cm. Anagnostopoulo et al.[6] found a strong, statistically significant relation between the corpus callosum longitudinal diameter (from genu to splenium) and the longitudinal diameter of the cerebrum. However, there was no association observed with the vertical diameter of the cerebral hemispheres. Mohammad et al.[11] also made a similar observation where the vertical cerebral diameter showed a positive linear correlation.

In the present study, we observed a significant correlation in the distance between the frontal and occipital poles as well as between the splenium and occipital pole (AB vs. BS). This finding suggests that the distance between the splenium and occipital pole (BS) grows more compared to that between the genu and frontal pole (AG), within the distance between the anterior and posterior poles (AB). We also found a stronger correlation between, O (G-S) and INCUR, O (G-S) and OUTCR, which means the outer curvature from genu to splenium grows more than its inner curvature I (GS), within the growth of the entire corpus callosum outer and inner curvature. It was observed that there is a very high statistical significance between I (G-S) and INCUR.

The structure of corpus callosum changes throughout the lifetime of an individual, however this is more, so in the adolescent period and childhood.[12] The temporary changes in the thickness of corpus callosum are due to the variation in the myelination of axons, pruning, and redirection.[12] The lengths of the cerebrum and the corpus callosum are greater in males than in females.[13] Unfortunately, in the present study, a gender-based comparison was not performed. In a magnetic resonance imaging study by Weis et al.,[14] it was reported that the genu and body of the corpus callosum were smaller in elderly individuals with regards to its width and thickness.[14] However, the present study did not compare dimensions of the corpus callosum with age.

In the present study, we found a highly significant correlation between the thickness of the genu and its distance from the fornix measured as G-F and G. A highly significant correlation was also found between genu to fornix distance and the inner curvature from genu to splenium measured as I (G-S) and G-F. This suggests some growth changes in the genu, which was not reported in earlier studies. Tomoluola et al.[10] reported from his study of corpus callosum morphometry in patients with congenital blindness; there was about 12 per cent decrease in the corpus callosum size and they had 20 per cent increase in the dimensions of the isthmus and the body. In a study by Davatzikos at al.[15] in children with periventricular leukomalacia, it was observed that the whole corpus callosum was significantly smaller in patients with severe versus mild cognitive impairments. The diagnosis of glioma or lymphoma of the cerebrum can be made if there is a bihemispheric callosal mass lesion in any of the parts of the corpus callosum as with the genu, body or splenium. Foster et al.[16] reported one such case of an expanding symmetrical mass at the splenium. In addition, a case of glioblastoma multiformes involving the splenium was reported by Kiely and Twomey.[17] The data and the correlation obtained in the present study are important to the radiologists. The data help in the comparison of the dimensions of corpus callosum with the data across the world. The comparison of the volume of corpus callosum in diseased patient with that of normal can be done. The morphometric data have implications in studying neurodegenerative diseases, as the fibre tracts of the corpus callosum can be traced by using diffusion tensor imaging and Voxel based morphology.

Conclusion

Morphometric changes in the dimensions of the corpus callosum may help in the diagnosis of any pathological conditions related to it. Corpus callosal morphometric data from the Southern Indians have been provided by the present study. This includes the topography of the corpus callosum from the cerebral frontal pole to the cerebral occipital pole. Despite limitations of sample size and a gender-based comparison, the data and correlation observed in the present study are of practical significance for neurologists, neurosurgeons, and radiologists.

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PEER REVIEW

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CONFLICTS OF INTEREST

The authors declare that they have no competing interests.

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None

PATIENT CONSENT

The authors, *Chettiar GK, Murlimanju BV, Krishnamurthy A, Prashanth KU, Rai R, Prameela MD,* declare that:

1. They have obtained written, informed consent for the publication of the details relating to the patient(s) in this report.
2. All possible steps have been taken to safeguard the identity of the patient(s).
3. This submission is compliant with the requirements of local research ethics committees.

Figure 1: Cadaveric brain section (mid-sagittal) showing the corpus callosum

Figure 2: Morphometric dimensions of the corpus callosum in the present study (AB-distance from frontal pole to occipital pole; CD-distance from inferior surface to the superior surface of the brain; AG-distance of frontal pole of the brain to the genu; BS-distance of the cerebral occipital pole to the splenium of the corpus callosum; (Ls-SC)- distance of splenium to the midbrain superior colliculus; (Ls-IC)- distance of splenium to midbrain inferior colliculus; GF- distance from genu to fornix).

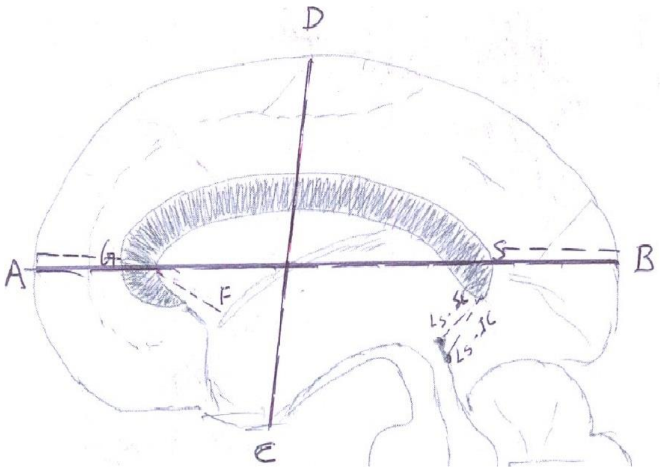

Figure 3: Morphometric dimensions of the corpus callosum in the present study (OUTCR-the whole outer curvature from the rostral end to the splenium; INCUR-the whole inner curvature from the rostrum to the splenium; O (G-S)-the outer curvature; I (G-S)-the inner curvature from genu to splenium; S-thickness of splenium; I-thickness of isthmus; T-thickness of trunk or body; G-thickness of genu; R-thickness of Rostrum of corpus callosum).

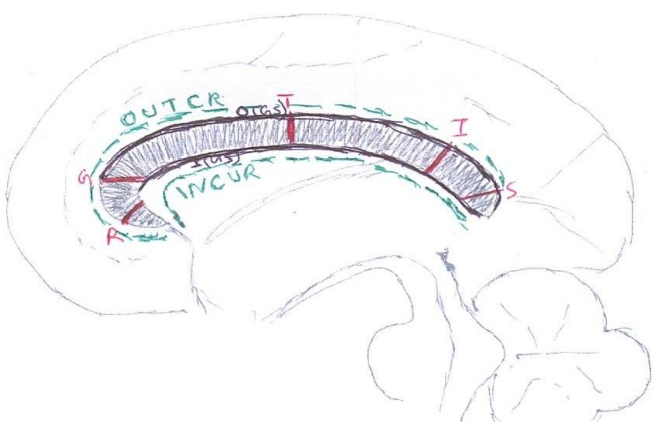

Table 1: Descriptive statistics of the data obtained in the present study

	N	Minimum	Maximum	Mean	Std. Deviation
A-B	20	14.2	17.3	15.186	0.841
C-D	20	7.05	10.04	9.087	0.707
A-G	20	2.81	4.8	3.321	0.435
B-S	20	3.65	6.34	5.113	0.551
O(G-S)	20	6.22	7.36	6.894	0.308
I(G-S)	20	4.27	5.16	4.787	0.265
OUTCUR	20	10.10	14.4	12.28	0.910
INCUR	19	6.50	9.0	7.50	0.856
G_F	20	2.15	2.9	2.449	0.220
Ls-SC	16	0.66	1.22	0.885	0.170
Ls-IC	16	0.97	1.66	1.236	0.227
R	20	0.51	0.75	0.620	0.078
G	20	0.81	1.3	1.108	0.166
T	20	0.49	0.82	0.634	0.107
S	20	0.84	1.24	1.027	0.113
I	20	0.3	0.58	0.438	0.089

Table 2: Statistical significance and the correlation of the parameters measured in the present study

		C-D	A-G	B-S	O(G-S)	I(G-S)	OUTCUR	INCUR	G_F	Ls-SC	Ls-IC
A-B	R	0.024	0.174	0.556	0.066	0.282	0.039	0.384	0.068	0.041	0.353
	P	0.919	0.462	0.011 sig	0.783	0.229	0.869	0.104	0.775	0.880	0.180
	N	20	20	20	20	20	20	19	20	16	16
C-D	R		0.089	0.019	0.121	0.060	0.169	0.313	0.058	0.579	0.622
	P		0.709	0.938	0.613	0.800	0.475	0.192	0.807	0.019 sig	0.01 hs
	N		20	20	20	20	20	19	20	16	16
A-G	R			0.369	0.261	0.027	0.295	0.091	0.031	0.181	0.016
	P			0.110	0.267	0.911	0.207	0.712	0.897	0.503	0.952
	N			20	20	20	20	19	20	16	16
B-S	R				0.153	0.161	0.073	0.129	0.144	0.034	0.162
	P				0.519	0.498	0.759	0.599	0.545	0.902	0.550
	N				20	20	20	19	20	16	16
O(G-S)	R					0.651	0.487	0.546	0	0.133	0.156
	P					0.002 hs	0.029 sig	0.016 sig	0.999	0.623	0.565
	N					20	20	19	20	16	16
I(G-S)	R						0.025	0.713	0.566	0.288	0.226
	P						0.917	<0.001 vhs	0.009 hs	0.280	0.401
	N						20	19	20	16	16
OUTCUR	R							0.077	0.386	0.023	0.036
	P							0.754	0.093	0.933	0.895
	N							19	20	16	16
INCUR	R								0.339	0.315	0.412
	P								0.156	0.252	0.127
	N								19	15	15
G_F	R									0.352	0.248
	P									0.181	0.355
	N									16	16
Ls-SC	R										0.901
	P										<0.001 vhs
	N										16

Table 3: Statistical significance and the correlation of parameters measured in the present study

		R	G	T	S	I
A-B	r	0.198	0.020	0.610	0.376	0.286
	p	0.403	0.935	0.004 hs	0.103	0.221
	N	20	20	20	20	20
C-D	r	0.024	0.295	0.079	0.107	0.279
	p	0.921	0.207	0.742	0.654	0.233
	N	20	20	20	20	20
A-G	r	0.476	0.401	0.068	0.142	0.267
	p	0.034 sig	0.080	0.777	0.549	0.255
	N	20	20	20	20	20
B-S	r	0.143	0.304	0.234	0.388	0.057
	p	0.548	0.192	0.32	0.091	0.812
	N	20	20	20	20	20
O(G-S)	r	0.268	0.222	0.165	0.373	0.339
	p	0.254	0.348	0.486	0.106	0.144
	N	20	20	20	20	20
I(G-S)	r	0.173	0.398	0.039	0.010	0.422
	p	0.466	0.083	0.872	0.968	0.064
	N	20	20	20	20	20
OUTCUR	r	0.304	0.294	0.188	0.607	0.372
	p	0.192	0.209	0.428	0.005	0.106
	N	20	20	20	20	20
INCUR	r	0.061	0.356	0.152	0.097	0.129
	p	0.805	0.135	0.535	0.692	0.599
	N	19	19	19	19	19
G_F	r	0.397	0.564	0.438	0.411	0.180
	p	0.083	0.010 hs	0.054	0.072	0.447
	N	20	20	20	20	20
Ls-SC	r	0.086	0.491	0.221	0.014	0.298
	p	0.752	0.053	0.410	0.960	0.262
	N	16	16	16	16	16
Ls-IC	r	0.308	0.469	0.133	0.250	0.016
	p	0.246	0.067	0.624	0.350	0.954
	N	16	16	16	16	16
R	r		0.350	0.206	0.143	0.097
	p		0.130	0.384	0.548	0.685
	N		20	20	20	20
G	r			0.115	0.298	0.019
	p			0.630	0.202	0.937
	N			20	20	20
T	r				0.701	0.543
	p				0.001 vhs	0.013 sig
	N				20	20
S	r					0.005
	p					0.984
	N					20