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Original Article

Morphometry of the Splenium of the Corpus Callosum – A Study on 60 Cadaveric Brains

Pervin S[1], Nurunnabi ASM[2], Ara S[3], Haroon K[4]

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Manuscript Preparation- Dr. Abu Sadat Mohammad Nurunnabi

Data Collection- Dr. Shahnaj Pervin , Prof. Shamim Ara, Dr.Abu Sadat Mohammad Nurunnabi

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Abstract:

Background: *The splenium is the posterior most part of the corpus callosum; age- and sex-related differences in splenial morphology may influence some behavioural and neuropsychological functions; however, controversies still prevail on sexual dimorphism of the splenium.*

Objective: *To provide data on morphology of the splenium of the corpus callosum in a Bangladeshi population.*

Materials and Methods: *This crosssectional, descriptive study was done in the Department of Anatomy, Dhaka Medical College, Dhaka, Bangladesh, from July 2009 to June 2010, based on collection of 60 adult human brains (36 male and 24 female) from the morgue of the same institution. The samples were divided into four age groups: A (20-29 years), B (30-39 years), C (40-49 years) & D (50-59 years).The length and width of the splenium were measured in formalin-fixed brain by using a digital slide calipers in mm.*

Results: *A total of 32 (52%) tubular shaped and 28 (47%) bulbous shaped splenium was found. Tubular shaped splenium was more observed in adult males, while bulbous shape was more evident in adult females; the difference was statistically significantinall age groups. The mean length of splenium was found 13.52±0.20 mm in group A, while 13.53±0.18 mm in group B, 13.46±0.05 mm in group C and 13.47±0.05 mm in group D ($p>0.05$). The mean length of the splenium was larger in male in comparison to female i.e. in group A (13.60±0.25 mm vs. 13.43±0.04 mm; $p<0.05$), in group B (13.61±0.20 mm vs. 13.40±0.01 mm; $p<0.01$), in group C, (13.50±0.02 mm vs. 13.40±0.01 mm; $p<0.001$) and in group D (13.50±0.01 mm vs. 13.40±0.01 mm; $p<0.001$). The mean width of splenium was found 10.41±0.32 mm in group A, while 10.39±0.19 mm in group B, 10.36±0.21 mm in group C and 10.32±0.20 mm in group D($p>0.05$). However, the mean width of the splenium was found greater in female than that of male, i.e. in group A (10.65±0.07 mm vs. 10.21±0.32 mm; $p<0.01$), in group B, (10.59±0.05 mm vs. 10.25±0.09 mm; $p<0.001$), in group C(10.61±0.04 mm vs. 10.20±0.03 mm; $p<0.001$), and in group D (10.60±0.03 mm vs. 10.20±0.02 mm; $p<0.001$).*

Conclusion: *Our data suggest that the splenium of the corpus callosum has gender-related variations; however, no age-related variation is evident.*

Key words: *Human brain, corpus callosum, splenium, sexual dimorphism.*

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Introduction:

The corpus callosum is the primary commissural region of the human brain consisting of white matter tracts that connect the left and right cerebral hemispheres[1], which is composed of near about 200 million heavily myelinated nerve fibers that form homotopic or heterotopic projections to contralateral neurons in the same anatomical layer[2]. Anatomically

1. Dr. Shahnaj Pervin, Associate Professor, Department of Anatomy, Popular Medical College, Dhaka, Bangladesh;
2. Dr. Abu Sadat Mohammad Nurunnabi, Assistant Professor, Department of Anatomy, OSD, Directorate General of Health Services (DGHS), Dhaka, Bangladesh;
3. Prof. Shamim Ara, Professor and Head, Department of Anatomy, Holy Family Red Crescent Medical College, Dhaka, Bangladesh;
4. Dr. Kaisar Haroon, Assistant Professor, Department of Clinical Neurosurgery, National Institute of Neurosciences &Hospital, Dhaka, Bangladesh.

Address of Correspondence: : Dr.Abu Sadat Mohammad Nurunnabi,Assistant Professor, Department of Anatomy, OSD, Directorate General of Health Services (DGHS), Dhaka, Bangladesh. Email: shekhor19@yahoo.com

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from anterior to posterior, the corpus callosum is composed of four parts: rostrum, genu, body and splenium[1,2]. The splenium is the posterior aspect of the corpus callosum; it connects the posterior cortices predominantlyparietal and temporal areas, and primary and secondary visual areas[3,4]. The functions of the splenium have not completely understood yet; however, splenial lesions may result in the disconnection between the cerebral hemispheres, with disruption of higher cortical function[4,5], loss of conscious processes[4,5] and initiate delirious behaviour in humans[5]. Hence, the difference in the length and width of the splenium are of great importance. The splenialarea found to be increased significantly with age in children and decreased significantly with age in adults[6,7]. Moreover, gradual shrinkage of the midsagittal surface as evident with age in women (but not in men) may also have concurrent shrinkage in the splenial area[7]. These anatomical gender-related differences may partly attribute differences in behaviour and neuropsychological function[7]. However, there are controversies among researchers around the globe[7-9]. Hence, wide ranging investigations are still demanded on the splenial morphology in different ethnicities in respect of age, sex,profession and neurophysiological and neuropsychiatric status. There is a lack of documented study to date on the splenium of the corpus callosumin Bangladeshi people. Literature suggested that postmortem material allows a more precise identification of the callosal borders and facilitates direct measurement[10]. Therefore, direct measurement in cadaveric specimen might be a better scope for those who are working in a resource-poor setting like Bangladesh. Considering the prospects, the present study was designed to investigate the possible gender- and age-related variations in the splenium of the corpus callosum by using anthropometric callosal measurements in cadaveric specimens.Dataderived from the study are expected toenrich the information pool in determining deviations from the normal value in various disease processes as well in surgical planning of intraventricular and callosal pathologies.

Materials and Methods:

This crosssectional, descriptive study was done in the Department of Anatomy, Dhaka Medical College, Dhaka, Bangladesh, from July 2009 to June 2010, based on collection of 60 adult human cadaveric brains. Cadaveric human brains were collected from the unclaimed dead bodies that were under examination in the Department of Forensic Medicine, Dhaka Medical College, Dhaka. After completion of all legal formalities and permission, the samples were collected within 24 to 36 hours of death. During collection of the samples appropriate age, sex and the cause of death were noted from the morgue's record book. Soon after collection, the sample was brought to Anatomy Dissection Hall and tagged immediately with code number for subsequent identification and dissection. Each sample was gently washed with tap water on a dissection tray. Blood and blood clots were removed as far as possible. Then the sample was fixed in 40% formaldehyde solution for 15 days.

To investigate possible variation with age and gender, the samples were classified into four age groups (Table I) (according to Junle et al.)[11].

Table-I

Grouping of the samples (n = 60)

Group	Age range	Number of samples	
		Male	Female
A	20-29 years	9	8
B	30-39 years	12	8
C	40-49 years	8	5
D	50-59 years	7	3

After fixation was done, samples were washed in running tap-water to eliminate excess formalin. Then the samples were kept on a metallic tray and cut carefully in the median plane by using sharp scissors, fine dissecting forceps and a BP blade along the longitudinal fissure from front to back. The falxcerebri containing superior and inferior sagittal sinus, fornix, septum pellucidum, interthalamic adhesion and brain stem were cut step by step; the hemispheres were divided into two halves (according to Romanes)[12]. These were put into another tray and the shape of the splenium of the corpus callosum was observed cautiously, as described by De Lacoste-Utamsing & Holloway[13] and recorded in the pre-formed data sheet. Then, the morphological measurements from both hemispheres were taken. Samples were put into another tray and the morphological measurements

from both hemispheres were taken. Overall, our exclusion criteria included – i)decomposed body, ii) any deep injury to the head, iii) grossly deformed brain, iv) if failed to extract total of the corpus callosum through dissection, and v) any visible deformity or pathology of the corpus callosum.

The posterior one fifth of total length of the corpus callosum is considered as the splenium (according to Witelson)[14]. Hence, the total length of corpus callosum (the distance from the anterior most point of the genu to the posterior most point of the splenium, according to Gupta et al.)[15] in both hemispheres was measured by using digital slide calipers in mm, and then divided by 5 to get the values as length of the splenium (Fig. 1). The perpendicular distance between two points at the dorsal and ventral margin of the splenium at its widest part is considered as the width of splenium (following Gupta et al.)[15]. The distances of these two points from both hemispheres were measured by using digital slide calipers in mm.

The morphometric data were recorded in a preformed data sheet, then processed to get mean values, standard deviations, percentage values, as applicable. Statistical analysis was done using SPSS version 13.0. The analysis of the shape of the splenium was done by Chi-square test, while comparison between different age groups was done by One-way ANOVA, and to compare between sexes unpaired Student's't' test was applied. p value<0.05 was considered as statistically significant.The present study was approved by the Ethical Review Committee ofDhaka Medical College, Dhaka, Bangladesh.

Results:

Shape of the splenium of the corpus callosum: A total of 32 (52%) tubular shaped and 28 (47%) bulbous shaped splenium were found. Tubular shaped spleniumwas observed more in males than females in all age groups, which was statistically significant (Table II). In contrast, bulbous shaped splenium was observed more in females than males in all age groups, which was also statistically significant (Table II).

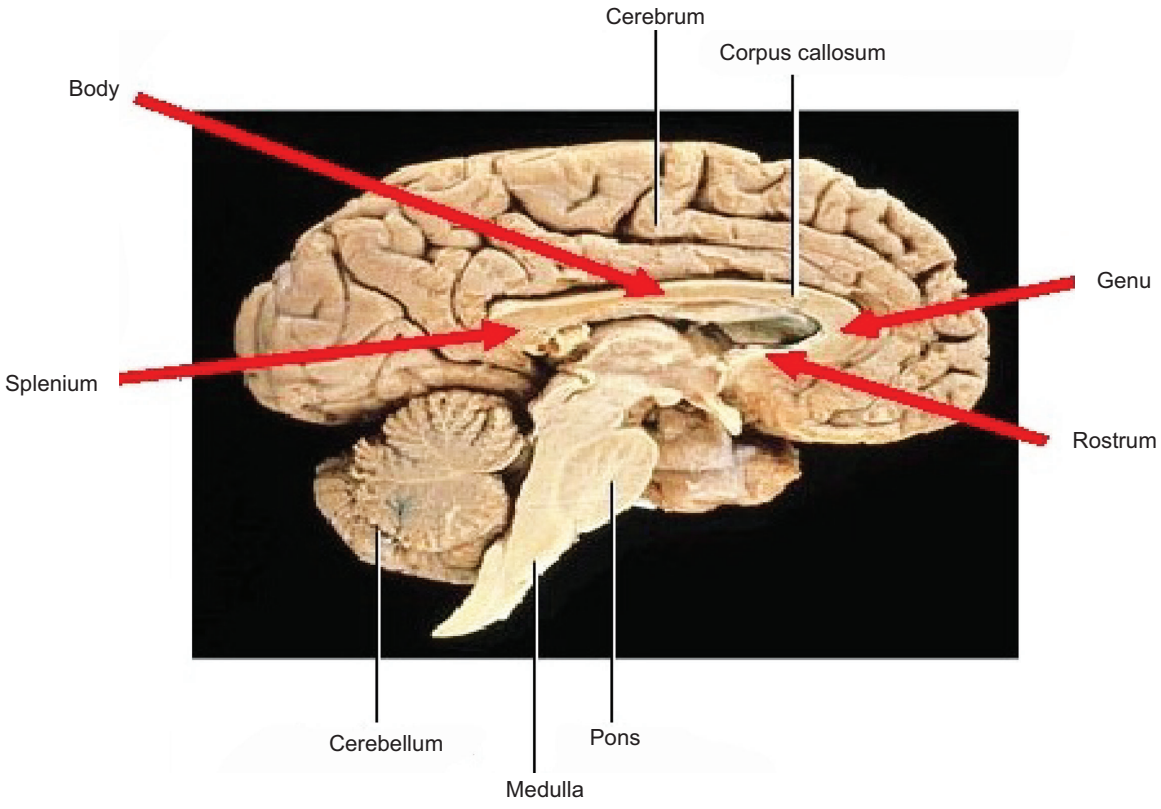

Fig.-1: *Mid-sagittal view of the cadaveric brain showing the corpus callosum and its parts: rostrum, genu, body and splenium (from anterior to posterior).*

Length of the splenium of the corpus callosum: The mean length of splenium was found 13.52±0.20 mm in group A, while 13.53±0.18 mm in group B, 13.46±0.05 mm in group C and 13.47±0.05 mm in group D. The difference of the length of splenium of corpus callosum among age groups was statistically not significant (p>0.05) (Table3a).The mean lengths of the splenium in male and female were 13.60±0.25 mm and 13.43±0.04 mm in group A (p>0.05), 13.61±0.20 mm and 14.40±0.01 mm (p<0.01) in group B, 13.50±0.02 mm and 13.40±0.01 mm (p<0.001) in group C and 13.50±0.01 mm and 13.40±0.01 mm in Group D (p<0.001) respectively. The differences of the length of splenium of corpus callosum between male and female in all age groups were statistically significant(Table IIIb).

*Width of the splenium of the corpus callosum:*The mean width of splenium was found 10.41±0.32 mm in group A, while 10.39±0.19 mm in group B, 10.36±0.21 mm in group C and 10.32±0.20 mm in group D. The difference of the width of splenium among age groups was statistically not significant (p>0.05) (Table IVa). The mean widths of the splenium in male and female were 10.21±0.32 mm and 10.65±0.07 mm in group A, 10.25±0.09 mm and 10.59±0.05 mm (p<0.001) in group B, 10.20±0.03 mm and 10.61±0.04 mm in group C and 10.20±0.02 mm and 10.60±0.03 mm in group D respectively. The differences of the width of splenium between male and female in all age groups were statistically significant (Table IVb).

Table-II

Shape of splenium of corpus callosum in male and female in different age groups (n=60)

Age group	Tubular (n=32)		Bulbous (n=28)		p value
	Male(n=29)	Female (n=3)	Male (n=7)	Female(n=21)	
A	6 (21%)	-	3 (43%)	8 (39%)	<0.01**
B	10 (34%)	1 (33%)	2 (29%)	7 (33%)	<0.01**
C	7 (24%)	2 (67%)	1 (14%)	3 (14%)	<0.01**
D	6 (21%)	-	1 (14%)	3 (14%)	<0.01**

Figures in parentheses indicate percentage. p value reached by Chi-square test, **= significant.

Table-III a

Length of splenium of corpus callosum in different age group (in mm)

Age group	Mean±SD	p value
A	13.52±0.20	A vs. B >0.05^{NS}
B	13.53±0.18	B vs. C >0.05^{NS}
C	13.46±0.05	C vs. D >0.05^{NS}
D	13.47±0.05	A vs. D>0.05^{NS}

p value reached by One-way ANOVA (Post Hoc), NS = not significant.

Table-III b

Length of splenium of corpus callosum of male and female in different age group (in mm)

Age group	MaleMean±SD	FemaleMean±SD	p value
A	13.60±0.25	13.43±0.04	<0.05*
B	13.61±0.20	13.40±0.01	<0.01**
C	13.50±0.02	13.40±0.01	<0.001***
D	13.50±0.01	13.40±0.01	<0.001***

p value reached by unpaired Student's 't' test, */**/*** = significant.

Table-IVa

Width of splenium of corpus callosum in different age group (in mm)

Age group	Mean±SD	p value
A	10.41±0.32	A vs. B >0.05^{NS}
B	10.39±0.19	B vs. C >0.05^{NS}
C	10.36±0.21	C vs. D>0.05^{NS}
D	10.32±0.20	A vs. D>0.05^{NS}

p value reached by One-way ANOVA (Post Hoc), NS = not significant.

Table-IVb

Width of splenium of corpus callosum of male and female in different age group (in mm)

Age group	Male	Female	p value
A	10.21±0.32	10.65±0.07	<0.01**
B	10.25±0.09	10.59±0.05	<0.001***
C	10.20±0.03	10.61±0.04	<0.001***
D	10.20±0.02	10.60±0.03	<0.001***

p value reached by unpaired Student's 't' test, **/*** = significant.

Discussion:

In present study, a total of 32 (52%) tubular shaped and 28 (47%) bulbous shaped splenium was found. Moreover, tubular shaped splenium was more observed in adult males, while bulbous shape was more evident in adult females. The results are supported by the findings of De Lacoste-Utamsing & Holloway[13] and Allen et al.[8].

We observed larger length of the splenium in males. However, our measurements are a bit larger than that of Mourgela et al.[16], as they reported that average lengths of the splenium were 0.79±0.14 cm in 24-45 years group, 0.73±0.21 cm in 46-65 years group and 0.70±0.12 cm in 66-80 years group (p=0.432), while 0.72±0.19 cm in male and 0.75±0.15 cm in female (p=0.594).However, Luders et al.[17] did an MRI study on the corpus callosum and found the length of the splenium19.92±2.71 cm in male and 17.62±1.60 cm in female;on an average the measurements were higher than that of the present study. However, Junle et al.[11] reported that splenium was proved to be larger in females, which is conflicting to our findings.

In the present study, the width of the splenium was found greater in females. Similar results were reported by Karaka et al.[18], as they found the mean widths splenium in male 11·90±1·94 mm and in female 12·52±1·35 mm and Suganthy et al.[19]– their values were 1.12 cm and 1.14 cm in male and female respectively. However, in contrast, Gupta et al.[20] reported that the splenial width values were 1.12 cm (male) and 1.01 cm (female) in the preserved brains while the corresponding MRI values were 1.15 cm (male) and 1.17 cm (female), as they studied on a North-West Indian population.

Our results also showed that the width of splenium slightly reduced with ageing (not statistically significant though), which is in agreement with the findings of Junle et al.[11], as they noted that posterior one third of splenium tends to decrease gradually with ageing. However, in other evidence, men exhibited significantly greater callosal width or thickness that may be attributable to larger brain dimensions in men[6]. Last but not the least, the differences found in measurements done directly in cadaver specimens and through MRI may be due to technical magnification of the image taken by MRI scan of brain[20].

To our knowledge, this is the first ever cadaveric study on corpus callosum in our country. Hence, no local reports have been found to compare with the present study.The sexual dimorphism of the corpus callosum has remained controversial as measurements have been performed in a variety of ways in different settings with different procedures and in different population. Moreover, the size of the corpora callosum may vary considerably among individuals, which requires a large

sample sizes to demonstrate significant sex differences in a population.

Conclusion:

Our data suggest that the splenium of the corpus callosum has gender-related variations; however, no age-related variation is evident. Hence, it may be concluded that the splenium of the corpus callosum is sexually dimorphic. However, further studies are recommended with larger sample, in multicentre settings, both in cadaveric and living brains, through MRI scan to compare with our findings and to enrich the information pool in our population.

References:

1. Crossman AR. Cerebral hemisphere. In: Standring S, Ellis H, Healy JC, et al. eds. Gray's anatomy: the anatomical basis of clinical practice. 40th ed. Edinburgh: Elsevier Churchill Livingstone; 2008: p.354-6.
2. Raybaud C. The corpus callosum, the other great forebrain commissures, and the septum pellucidum: anatomy, development, and malformation. Neuroradiology. 2010;52(6):447-77. DOI: https://doi.org/10.1007/s00234-010-0696-3.
3. Clarke S, Kraftsik R, van der Loos H, Innocenti GM. Forms and measures of adult and developing human corpus callosum: is there sexual dimorphism? J Comp Neurol. 1989;280(2):213-30.DOI: https://doi.org/10.1002/cne.902800205
4. De Lacoste MC, Kirkpatrick JB, Ross ED. Topography of the human corpus callosum. J NeuropatholExpNeurol. 1985;44(6):578-91.DOI : https://doi.org/10.1097/00005072-198511000-00004.
5. Takanashi J, Tada H, Kuroki H, Barkovich AJ. Delirious behavior in influenza is associated with a reversible splenial lesion. Brain Dev. 2009;31(6):423-6. DOI: https://doi.org/10.1016/j.braindev.2008.07.013.
6. Weis S, Kimbacher M, Wenger E, Neuhold A. Morphometric analysis of the corpus callosum using MR: correlation of measurements with aging in healthy individuals. Am J Neuroradiol. 1993;14(3):637-45.
7. Allen LS, Richey MF, Chai YM, Gorski RA. Sex differences in the corpus callosum of the living human being. J Neurosci. 1991;11(4):933-42. DOI: https://doi.org/10.1523/JNEUROSCI.11-04-00933.1991.
8. Constant D, Ruther H. Sexual dimorphism in the human corpus callosum? A comparison of methodologies. Brain Res. 1996;727(1-2):99-106. DOI: https://doi.org/10.1016/0006-8993(96)00358-7.
9. Sullivan EV, Rosenbloom MJ, Desmond JE, Pfefferbaum A. Sex differences in corpus callosum size: relationship to age and intracranial size. Neurobiol Aging. 2001;22(4):603-11. DOI: https://doi.org/10.1016/S0197-4580(01)00232-9.
10. 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.
11. Junle Y, Youmin G, Yanjun G, Mingyue M, Qiujuan Z, Min X. A MRI quantitativestudy of corpus callosum in normal adults. J Med Coll PLA 2008;23(6):346-51.DOI: https://doi.org/10.1016/S1000-1948(09)60005-8.
12. Romanes GJ. The cerebrum. In: Cunningham's manual of practical anatomy. Vol. 3. 15th ed. Oxford: Oxford University Press; 2002: p.249-63.
13. De Lacoste-Utamsing C, Holloway RL. Sexual dimorphism in the human corpus callosum. Science. 1982;216(4553):1431-2.DOI: 10.1126/science.7089533.
14. Witelson SF. Hand and sex differences in the isthmus and genu of the human corpus callosum: a postmortem morphological study. Brain. 1989;112(Pt 3):799-835. DOI: https://doi.org/10.1093/brain/112.3.799.
15. 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.
16. 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.
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: https://doi.org/10.1093/cercor/13.10.1084.
18. Karakaþ P, Koç Z, Koç F, GülhalBozkýr M. Morphometric MRI evaluation of corpus callosum and ventricles in normal adults. Neurol Res. 2011;33(10):1044-9. DOI: https://doi.org/10.1179/1743132811Y.0000000030.
19. 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: https://doi.org/10.1002/ca.10161.
20. Gupta T, Singh B, Kapoor K, Gupta M, Kochhar S. Normative data of corpus callosal morphology in a North-West Indian population – an autopsy and MRI study. J Nepal Med Assoc. 2009;48(173):46-51.PMID: 19529058 .