An MRI study of age and sex related developmental changes in corpus callosum in punjabi population

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ABSTRACT

Introduction: The corpus callosum is the largest and the primary commissure of the brain connecting the left and right cerebral hemispheres.It integrates and transfer information from both cerebral hemispheres to process sensory, motor, and high-level cognitive signals. MRI is rapidly becoming an important tool for assessing corpus callosum. Establishment of normal parameters will help in diagnosis as well as treatment of various disorders.

Objectives:To track the development of corpus callosum and explore the sexrelated and age related differences in various age groups.

Material and methods: In a cross-sectional retrospective study, a sample of 100 healthyindividuals, in a tertiary care hospital were segregated into various subgroups –infants(0-2),children (2-10), adolescent (10-18), young adult (18-25),middle age adults(25-45),older adults (45-65) and elderly (65 and above).The size of CC was measured onmidsagittal section in T1 images (TR-450ms and TE-8.7ms) on 1.5 Tesla SeimensMagnetom scanner.The cross-sectional area of seven segments ofthe CC– rostrum , genu , rostral body , anterior midbody , posterior midbody , isthmus andsplenium were calculated and correlated with brain dimensions: AB (maximum longitudinaldimension), CD (maximum vertical dimension) and EZ(total longitudinal dimension of CC). The data was assessed using Spearman correlations, Anova tests and Mann-Whitney tests.

Results: There was significant effect of age groups on the dimensions of various segments of CC. While no significant effect was observed of gender on the dimensions of corpus callosum. The brain dimensions: AB and CD tend to be smaller in women. The brain and corpus callosum both decreased in size with age. There was significant intersegmental correlation of brain and CC dimensions.

Conclusions: MRI is a valuable and easily available modality for assessment of development of corpus callosum. The study will help in forming normal database for corpus callosum, for studying and diagnosing various disease processes.

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INTRODUCTION

The corpus callosum is the primary commissure of the brain,connecting the left and right cerebral hemispheres. It integrates and transfer information from both cerebral hemispheres to process sensory, motor, and

high-level cognitive signals. The axons that form the corpus callosum arise primarily from neurons in neocortical layers II/III, V, and VI. At 12 to 13 weeks of gestation, nerve fibers begin to cross the midline, giving rise to connections that later become the corpus callosumThe internal carotid artery network provides arterial blood supply to most of the corpus callosum, specifically via the pericallosal artery (a branch of the anterior cerebral artery). The splenium is the exception as it receives vascular input from the vertebrobasilar system

The individual characteristics of brain as well as its parts like corpus callosum are subject to variation due to age, gender, race etc. Collecting data in normal subjects will help in forming a database against which comparisons can be done in various conditions like Alzheimer's, dementias, etc. Various measures of corpus callosum can also help in planning the interventions for treatment.

MATERIAL AND METHODS

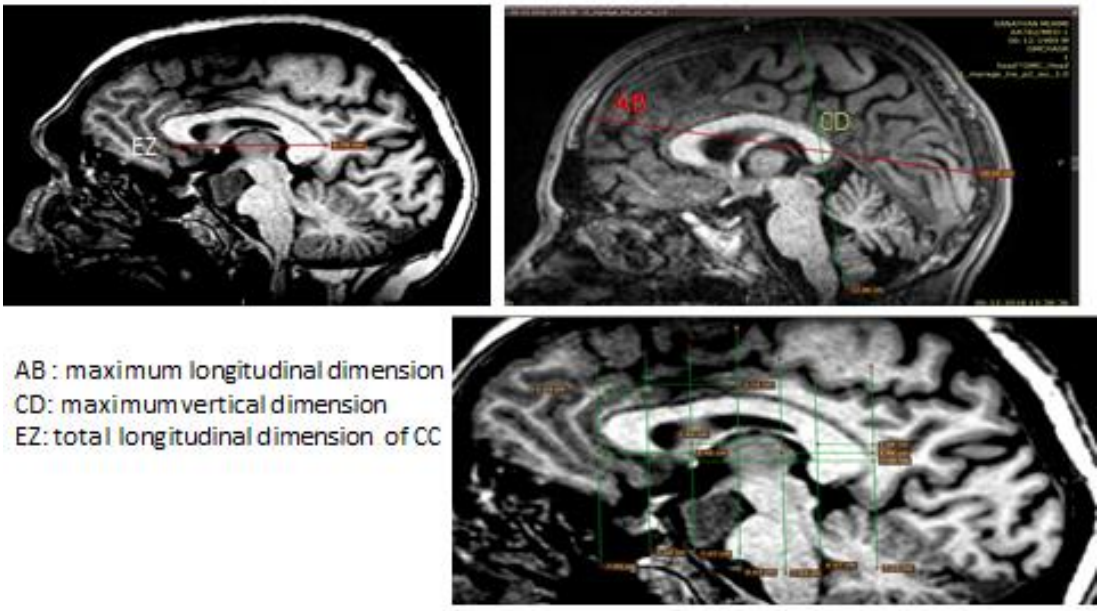
The study was done as a retrospective review on 100 healthy patients referred for MRI examination of head. The patients who theoretically could show abnormalities in corpus callosum were excluded, e.gtumour, schizophrenia, multiple sclerosis, old infarct, HIE, etc. Cases where images were in slightly oblique mid sagittal were also excluded.

The subjectswere segregated into various subgroups –infants(0-2),children (2-10), adolescent (10-18), young adult (18-25),middle age adults (25-45) ,older adults (45-65) and elderly (65 and above).

Total number of males were 59 and females were 41.

IMAGE ANALYSIS

The study was done on mid-sagittal section of head on T1 images(TR-450ms and TE- 8.7ms) on 1.5 Tesla SiemensMagnetomscanner. The various parameters measured included maximum longitudinal dimensions and maximum vertical dimensions of brain(AB and CD respectively),



AB: maximum longitudinal dimension; CD: maximum vertical dimension; EZ: total longitudnal dimension of corpus callosum.

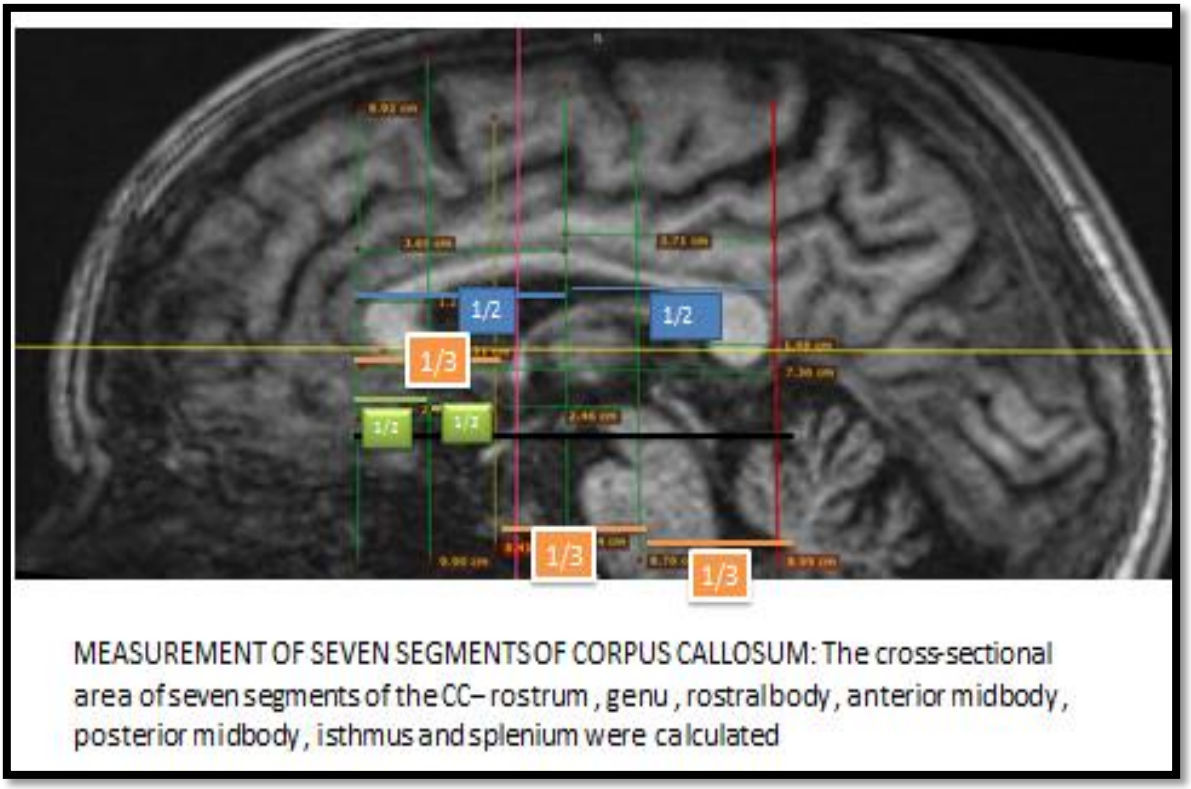
To measure the total length of corpus callosum(EZ),a perpendicular line was drawn through anterior most part of corpus callosum and another one through posterior most part of corpus callosum. The distance between two perpendicular lines gave us EZ.

THE corpus callosum was subdivided and cross-sectional area of seven segments of corpus callosum: genu, rostrum, rostral body, anterior mid body, posterior midbody, isthmus and splenium was assessed. First, the corpus callosum was divided longitudinally

into three equal parts with the help of perpendicular lines. Anteriormost one-third part was further subdivided into two equal parts: .anterior most half of this gave rostrum and posterior half gave genu. The inturn of corpus callosum not included in rostrum and was labelled rostral body.

In second step, anterior midbody and posterior midbody were measured. A perpendicular is drawn to divide the corpus callosum into two equal halves. The part between the anterior one-third and bisector gives anterior mid body. In a similar measurement, posterior to bisector is posterior mid body.

Third step includes measuring splenium and isthmus. A perpendicular divides posteriormost part into one-seventh section. This is splenium. The part between posterior most one-third divider and one-seventh divider gives isthmus [1].



MEASUREMENT OF SEVEN SEGMENTS OF CORPUS CALLOSUM: The cross-sectional area of seven segments of the CC– rostrum , genu , rostral body , anterior midbody , posterior midbody , isthmus and splenium were calculated

STATISTICAL ANALYSIS

Was done using Anova test, Mann-Whitney and Spearman correlations.Various tests like KOLMOGOROV – SMIRNOV testand SHAPIRO-WILK test were applied to assess correlation in various measurements.Means were calculated for various measurements and correlations were studied between different age groups as well as gender variation within the age group. Probability 'p' value ≤ 0.05 was considered significant.

RESULTS

According to our study, there is ,there is significant variation between both sexes only in horizontal and vertical dimensions of the brain (AB and CD).

Individual measures of brain, i.e, AB and CD as well as total length of corpus callosum show significant variation with age. AB increases in both sexes from birth till 18years of age and then remains more or less stable, a small decrease after 65 years is noted in females. Similarly maximum increase in size of CD as well as EZ (total length of corpus callosum) is seen only till 18-25years age group.

Different parts of corpus callosum show significant variation in measurements with age. . Significant increase is noted in the all the parameters from <2 years to 2- 10 years

age group and less significantly till 10 -18 years age group . Later there is only minimal variation in various measurements or some decrease is noted around 45 years or more. This variation was found to be more significant in all parts in case of males. In females, significant variation with age was observed only in case of genu and splenium.

Table 1: Measurements of AB, CD and EZ in various age groups.(in mm.)

Age Gps	Gender	N	AB: Mean±S.D.	CD:Mean±S.D.	EZ: Mean±S.D.
≤2	M	9	121.46±10.93	105.93±18. 70	48.79±6.11
	F	4	127.58±2.7	85.69±50.09	51.43±5.91
>2-10	M	6	151.77±8.16	124.03±9.14	63.23±5.32
	F	5	142.86±7.72	117.86±8.96	61.78±4.16
>10-18	M	3	168.47±5.21	125.57±2.40	71.23±3.40
	F	5	157.12±6.50	126.86±3.10	66.92±7.55
>18-25	M	7	160.90±6.07	131.93±5.59	69.77±4.27
	F	4	148.83±6.30	120.53±6.94	66.23±8.50
>25-45	M	14	161.75±13.00	134.34±12.44	71.91±4.54
	F	11	156.86±5.27	121.88±5.93	70.67±3.46
>45-65	M	14	168.88±8.80	132.18±6.02	75.76±4.24
	F	11	164.28±6.72	127.47±4.25	75.40±3.71
>65	M	6	168.37±12.25	125.15±9. 80	75.05±4.16
	F	1	143.40±0.00	115.3200±.	75.60±0.00
Total	M	59	157.19±18.85	126.78±14.23	68.44±10.18
	F	41	153.21±12.44	119.67±18.84	68.21±8.55

Table 2: Measurements of individual subdivisions: MEAN ± S.D.

AGE GP	SEX	N	Rostrum	GENU	Rostral Body	AMB	PMB	ISTHMUS	SPLENIUM
≤2	M	9	8.23±2.69	46.90±23.81	33.90±14.57	27.24±11.42	36.47±40.14	16.58±7.49	64.93±28.05
	F	4	9.40±2.30	60.68±7.09	33.15±17.78	29.22±11.50	25.45±9.82	16.47±6.02	48.60±9.58
>2-10	M	6	16.52±3.35	110.13±13.51	54.64±16.24	54.18±16.25	48.37±12.43	35.09±13.11	111.89±33.75
	F	5	13.46±5.40	112.70±9.71	42.74±9.26	42.51±4.32	39.74±3.69	21.64±4.79	103.55±21.44
>10-18	M	3	18.37±8.83	128.43±20.61	70.09±7.84	58.71±7.91	52.07±3.52	37.27±2.68	174.21±7.00
	F	5	19.76±8.80	134.98±23.17	56.66±18.11	58.65±14.50	49.36±10.95	48.19±19.51	145.52±37.36
>18-25	M	7	20.85±5.10	148.26±29.87	56.94±14.26	60.89±12.11	52.74±11.83	38.23±11.65	141.74±27.33
	F	4	19.26±7.92	114.28±51.62	59.03±20.84	62.79±29.32	58.67±27.96	28.09±9.53	129.60±55.86
>25-45	M	14	24.78±6.76	147.45±24.22	68.82±13.03	68.98±11.17	63.41±10.66	46.10±8.38	168.72±34.55
	F	1	23.95±3.	134.77±19	66.33±10.	64.78±10	59.32±11	39.17±12.	161.44±29.

		1	95	.99	84	.68	.21	52	65
>45-65	M	14	18.98±5.57	129.43±40.12	62.71±17.29	59.33±14.22	54.82±14.44	37.57±9.31	148.57±25.87
	F	11	18.41±5.11	136.99±16.20	62.49±14.56	68.81±8.60	59.66±11.10	48.81±11.26	152.31±21.23
>65	M	6	24.45±9.94	90.79±55.48	51.92±13.90	54.07±13.06	47.86±13.26	33.44±12.71	141.04±37.97
	F	1	10.48±0.00	127.59±0.00	65.03±0.00	58.92±0.00	58.62±0.00	33.50±0.00	151.92±0.00
Total	M	59	19.21±7.95	117.41±46.72	57.54±18.25	55.82±17.94	52.31±20.29	35.78±13.08	136.59±45.27
	F	41	18.47±6.91	123.30±30.85	57.26±17.22	58.59±17.43	52.42±16.36	37.29±16.00	135.64±43.90

Table 3: Showing correlation factors between different age groups, in relation to various parts of corpus callosum.significance (≤0.05)

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AGE GP	AB		CD		EZ		ROSTRUM		GENU		ROSTRAL BODY		AMB		PMB		ISTHMUS		SPLENIUM	
	K-S	S-W	K-S	S-W	K-S	S-W	K-S	S-W	K-S	S-W	K-S	S-W	K-S	S-W	K-S	S-W	K-S	S-W	K-S	S-W
≤2	**0.032**	**0.012**	**0.03**	**0.006**	0.2	0.219	0.2	0.713	0.115	0.081	0.2	0.322	0.076	0.209	**0**	**0**	**0.054**	0.194	0.2	0.577
≥2-10	0.2	0.66	0.079	0.148	0.2	0.87	0.2	0.486	0.2	0.567	**0.008**	**0.049**	**0.041**	**0.037**	0.2	0.454	**0.034**	**0.015**	0.2	0.735
≥10-18	0.2	0.962	0.2	0.554	0.2	0.434	0.2	0.459	0.2	0.709	0.104	0.183	0.2	0.797	0.2	0.9	0.2	**0.056**	0.113	0.077
≥18-25	0.2	0.987	0.2	0.251	0.2	0.828	0.2	0.761	0.154	0.36	0.111	0.145	0.2	0.824	0.2	0.903	0.175	0.661	0.2	0.157
≥25-45	0.1	**0.001**	102	**0.01**	**0.025**	**0.017**	0.2	0.385	0.2	0.204	0.2	0.075	0.173	0.541	**0.024**	**0.035**	0.2	0.759	0.2	0.075
≥45-65	0.2	0.329	0.2	0.124	0.2	0.551	0.2	0.422	0.12	**0**	0.109	0.312	**0.022**	**0.001**	**0**	**0.04**	0.2	0.491	0.2	0.398
≥65	0.2	0.122	0.2	0.927	0.2	0.541	0.2	0.653	0.2	0.273	0.2	0.491	0.2	0.241	0.2	0.744	0.2	0.553	0.2	0.412

Table 4: Gender related differences and significance factors

Measurements	Sex	Kolmogorov-smirnov	Shapiro-wilk
AB	MALE FEMALE	0.000 0.947	0.000 0.055
CD	MALE FEMALE	0.002 0.000	0.001 0.000
EZ	MALE FEMALE	0.000 0.102	0.000 0.023
ROSTRUM	MALE FEMALE	0.200 0.083	0.643 0.135
GENU	MALE FEMALE	0.017 0.010	0.001 0.002
ROSTRAL BODY	MALE FEMALE	0.004 0.200	0.027 0.440
ANTERIOR MIDBODY	MALE FEMALE	0.019 0.200	0.010 0.317
POSTERIOR MIDBODY	MALE FEMALE	0.019 0.200	0.000 0.603
ISTHMUS	MALE FEMALE	0.002 0.200	0.072 0.344

SPLENIIUM	MALE FEMALE	0.094 0.200	0.429 0.019

LIMITATION

1. The sample size in individual age group was very small.
2. Only measurements of various areas of corpus callosum were taken. No comparison was done between various measurements.
3. No correlation was done with handedness of the subject with corpus callosum.

DISCUSSION

Measurement of AB(maximum longitudinal dimension); CD(maximum vertical dimension:AB , CD shows significant variation with age in our study. There is increase in the longitudinal as well as vertical diameters of brain with age with positive correlation(table3) between diferrent age groups.These dimensions increase in both sexes from birth till 18years of age and then remains more or less stable, a small decrease after 65 years is noted, more so in females in our study.(fig3,4).

The mean AB across various age groups in our study was 157.19± 18.85mm in males while in females is 153.21± 12.44mm .For CD the mean for males was126.78± 14.23mm, while females had a mean of 119.67±18.84mm .According to KOLMOGOROV – SMIRNOV test and SHAPIRO- WILK test , there is significant variation between both sexes in the horizontal and vertical dimensions of the brain (AB and CD)as well as the total longitudinal dimension of corpus callosum..(table 1 and table 4).

Similar results were found in a study done by MourgelaS et al[2] on dimensions of brain and corpus callosum on MRI and Mohammadi M.R. et al[3] on corpus callosum. Mohammadi et al and Garel et al have found larger sizes in males compared to females, a difference registered in our study also.

Measurement of EZ(total longitudnal dimension of corpus callosum):The mean values for EZ were found to be 68.44± 10.18 mm and 68.21±8.55 mm in males and females, respectively. there is positive correlation between different age groups in the total longitudinal dimensions of corpus callosum. There is an increase in both sexes till 18-25 years age group followed by a plateau till 65years , when it shows a small decrease. Between the sexes there is asignificant variation in total length of corpus callosum(p-0.023).

Values for longitudinal dimensions of CC were 70.6±0.052 according to Mohammadi M.R. et al[3], which is well within the range derived in our study.Laissy et al[4] in their study on 243 subjects found mean CC length 7.06 ± 0. 48, which is slightly higher than our results.Gupta Tetal[5] found the total length of corpus callosum to be 7.57cm in males and 7.1cm in females on MRI scans while in preserved specimens the measurements were 6.98cm and 6.86cm respectively.our study correlates better with preserved specimen study. Ardaet al[6] had similar results (males: 68.56± 4.98mm, females: 67.53± 4.9)

Pujol et al[7] reported that the size of corpus callosum increases upto mid-twenties , with a more rapid growth in earlier years . Our results corroborate with the results of Garel C et al[8] also, who found progressive increase in size of CC throughout childhood. Gupta E et al[9]conducted study only on female subjects and found a decrease in thickness of CC with age. Luderset al[10]also found significant positive correlation in the growth of CC across various age groups. The growth was most significant in posterior midbody and splenium in their study

Tanaka-arakawaM.M.etal[1] studied the developmental changes in corpus callosum from infancy to early adulthood . According to their study, all parts of corpus callosum as well as overall corpus callosum increased markedly in size in both sexes upto 2years of age. Later their was a gradual flattening of the growth curve in both sexes, around 16years in females and 17years in males. They did not find significant variations in overall dimensions in males compared to females, which was in contrast to our study, where there is significant variation in the dimensions of EZ between both sexes . However, Mohammadi M.R. et al[3]found dimensions of

corpus callosum higher in males than females..Larger length of corpus callosum in males I comparison to females was also found by MourgelaS et al[2], Gupta T et al[11], Suganthy etal[12] and Elster etal[13].

MEASUREMENTS OF INDIVIDUAL AREAS OF CORPUS CALLOSUM

In our study, there is significant variations in various parts of CC within different age groups. Significant increase is noted in the all the parameters from <2 years to 2- 10 years age group and less significantly till 10 -18 years age group . Later there is only minimal variation in various measurements or some decrease is noted around 45 years or more.

There is significant variation in various parameters of corpus callosum with age in males but there is significant variation, with age, only in the sizes of genu and splenium , in case of females.However when various measurements were compared in different age groups, there was significant correlation in different parameters of CC with age.

The results are similar to study conducted by Tanaka-arakawaM.M.etal[1]. The genu and splenium was significantly smaller in children, who had smaller sizes than adolscents and adults group. Rostral midbody, posterior midbody, and anterior midbody were smallest in infants compared to adolscents. The rate of growth of different parts of corpus callosum was different in both sexes. In females, their was more significant variation in growth of anterior areas(genu, rostrum) compared to consistent pattern of growth in middle and posterior regions . In males, the growth was similar in all parts of corpus callosum, except rostrum.This increase in callosal thickness was also observed by Ludersetal[9].This difference in growth across regions was less significant in males compared to females. Males showed greater growth in anterior regions compared to females.

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