

A study on the age related anatomical variations of some of the cerebral cortical sulci of human brain



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Submission: 22-12-2020

Revision: 26-03-2021

Publication: 01-05-2021

ABSTRACT

Background: The sulcal patterns may be useful in studying the mechanisms of both neuro developmental and neuro degenerative changes that occur during brain maturation and aging. Magnetic resonance imaging has facilitated the non-invasive study of human cerebral and cognitive development. **Aims and Objective:** To find out the age related anatomical variations of some of the cerebral cortical sulci and gyri of the brain. **Materials and Methods:** The study was done using the MRI images of brain of normal healthy adults aged between 20-70 years. A total of 200 images were analysed consisting of that from 119 male subjects and 81 female subjects from the Department of Radiodiagnosis, Government Medical College Kottayam. **Results:** Using statistical analysis it was found that as the age advances there was decrease in the depth, in case of central sulcus, pre-central sulcus and post-central sulcus. The width of the pre-central sulcus and post-central sulcus was found to increase with age. The changes in the width of the central sulcus were not significant. **Conclusion:** The observations of the undertaken study indicated that age changes do occur in the sulci of the brain and there was a sequential change in relation to the different periods of adult life. These changes are probably due to the volume loss of the brain due to the atrophy that occurs during aging.

Key words: Sulci; Gyri; Depth and Width of sulci; MRI images; Aging

INTRODUCTION

The cerebrum is the largest part of the brain. It is divided into right and left cerebral hemispheres by the median longitudinal fissure. The outer layer of the cerebral hemisphere consists of gray mater called cerebral cortex.¹ The mechanical process of gyral and sulcal folding occurs during brain development in gyrencephalic species, such as humans.² This folding occurs in order to accommodate the highly extensive cerebral cortex within the rigid cranial cavity.³ The central sulcus begins by cutting the superomedial border of the hemisphere about 1cm behind the midpoint between the frontal and occipital poles, runs sinuously downwards and forwards at an angle of 70° and ends above the posterior ramus of the lateral sulcus. Its upper end usually extends onto the medial surface. The

central sulcus forms the boundary between the motor and sensory areas of the cerebral hemisphere. This sulcus serves as a key to localize the other sulci and gyri.

The pre-central sulcus runs downwards and forwards parallel to and a little anterior to the central sulcus. The post-central sulcus runs downwards and forwards parallel to and a little posterior to the central sulcus.⁴ Aging is commonly defined as the accumulation of diverse deleterious changes occurring in cells and tissues with advancing age that are responsible for the increased risk of disease and death.⁵ Sulcal and gyral patterns reflect the effects of both maturational and neurodegenerative processes.⁶ The sulcal and gyral patterns reflect brain maturation processes and may indicate the effects of abnormalities in development due to either genetic or environmental factors. Based on these facts and

Access this article online

Website:

<http://nepjol.info/index.php/AJMS>

DOI: 10.3126/ajms.v12i5.33596

E-ISSN: 2091-0576

P-ISSN: 2467-9100

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observations, it was thought worthwhile to study the age changes of the major sulci and gyri of the brain.

MATERIALS AND METHODS

The radiological images for the study were obtained from the Radiodiagnosis Department Medical college Kottayam. A total of 200 MRI films of normal human brain of subjects in the age group of 20-70 years were analysed. The study subjects consisted of 119 males and 81 females. The collected images were categorized to different decades, from 20-70 years of age and the study period was 1 year from February 2012 to February 2013. Subjects with known endocrinal or psychiatric or neurological illness, head injury patients and patients with obvious pathology like swelling of brain were excluded from the study. The straight measurements were taken using software called J RULER. The sinus measurements were taken using software called GEOGEBRA. The measurements were taken using the Inverted Window method which makes the details of the sulci and gyri more obvious.

The width of the sulci and gyri were measured at intervals of 1.5 mm and the average was taken. The depth and width of the central, pre-central, post-central sulci were found using axial sections. The different dimensions of the sulci and gyri obtained were tabulated and the images were photographed. The tabulation works were followed by statistical analysis. The relation between age groups and different dimensions was analysed using ANOVA test.

Ethics

The procedures followed were in accordance with the ethical standards of the Institutional ethics committee of Government Medical College Kottayam.

Statistics

All data were collected, compiled and analysed using Microsoft Excel. Data analysis was done using ANOVA test. A p-value of <0.05 was considered to be significant

RESULTS

The mean depth of the central sulcus (in centimetres) was found to be 4.47 in the age group 20-30 years, 4.38 in the age group 31-40 years, 4.03 in the age group 41-50 years, 2.71 in the age group 51-60 years, 2.153 in the age group >60 years. P value was 0.001. The depth was found to decrease as the age advances and was statistically significant (Table 1).

The mean depth (in centimetres) of the pre-central sulcus was found to be 4.20 in the age group 20-30 years, 3.34 in the age group 31-40 years, 3.024 in the age group 41-50 years, 2.41 in the age group 51-60 years and 1.68 in

the age group >60 years. P value was 0.001 which was statistically significant (Table 2).

The mean depth (in centimetres) of the post-central sulcus was found to be 2.93 in the age group 20-30 years, 2.77 in the age group 31-40 years, 2.34 in the age group 41-50 years, 2.76 in the age group 51-60 years and 2.10 in the age group of >60 years. P value was 0.001. The depth was found to decrease with increasing age except in the age group 51-60 years where there was an increase in the mean depth compared to the other age groups (Table 3).

The mean width (in centimetres) of central sulcus was found to be 0.21 in the age group 20-30 years, 0.23 in the age group 31-40 years, 0.25 in the age group 41-50 years, 0.25 in the age group 51-60 years, 0.23 in the age group >60 years. There was widening of the central sulcus as age advanced. P value was 0.317. The difference was found to be non-significant (Table 4).

The mean width (in centimetres) of pre-central sulcus showed an increase with advanced age and was found to be 0.20 in the age group 20-30 years, 0.18 in the age group 31-40 years, 0.20 in the age group of 41-50 years, 0.21 in

Table 1: The depth of the central sulcus in relation to different age groups

Age group (in years)	Mean (cm)	N	Standard deviation
20-30	4.47250	40	.794422
31-40	4.37875	40	.691042
41-50	4.03000	40	.796161
51-60	2.71400	40	.621659
>60	2.15250	40	.485184
Total	3.54955	200	1.162687

Table 2: The depth of the pre-central sulcus in relation to different age groups

Age group (in years)	Mean (cm)	N	Standard Deviation
20-30	4.20200	40	.619943
31-40	3.33650	40	.572491
41-50	3.02425	40	.544341
51-60	2.40775	40	.542381
>60	1.67675	40	.502187
Total	2.92945	200	1.017571

Table 3: The depth of the post-central sulcus in relation to different age groups

Age group (in years)	Mean (cm)	N	Standard deviation
20-30	2.92625	40	.406118
31-40	2.76500	40	.692046
41-50	2.34075	40	.545360
51-60	2.76275	40	.687728
>60	2.10375	40	.416861
Total	2.57970	200	.637187

the age group 51-60 years, 0.27 in the age group of >60 years. P value was .001. The difference was found to be statistically significant (Table 5).

In 20-30 years of age, the mean width (in centimetres) of post-central sulcus was found to be 0.21 in the age group, 0.36 in the age group of 31-40 years, 0.25 in the age group 41-50 years, 0.24 in the age group 51-60 years, 0.46 in the age group >60 years. The difference was found to be statistically significant with a P value of 0.001 (Table 6).

In 20-30 years of age, the mean width (in centimetres) of post-central sulcus was found to be 0.21 in the age group, 0.36 in the age group of 31-40 years, 0.25 in the age group 41-50 years, 0.24 in the age group 51-60 years, 0.46 in the age group >60 years. The difference was found to be statistically significant with a P value of 0.001 (Table 7). Histogram shown in Figure 1 and 2 shows width and depth of sulci in different age groups of the study subjects.

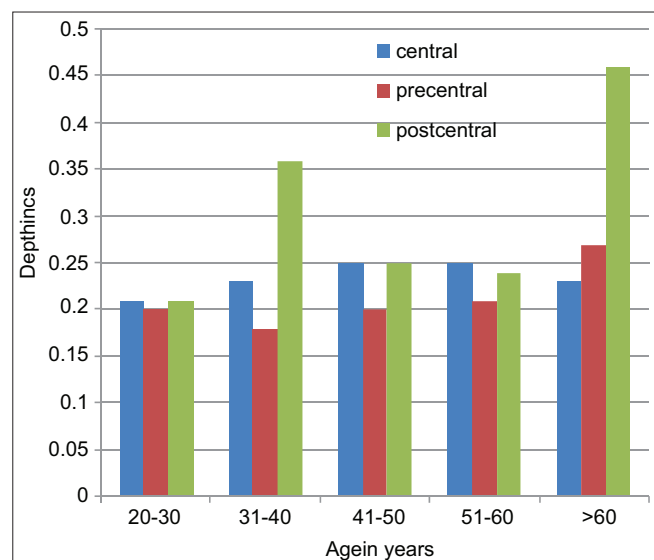


Figure 1: Histogram showing depth of the sulci in different age groups

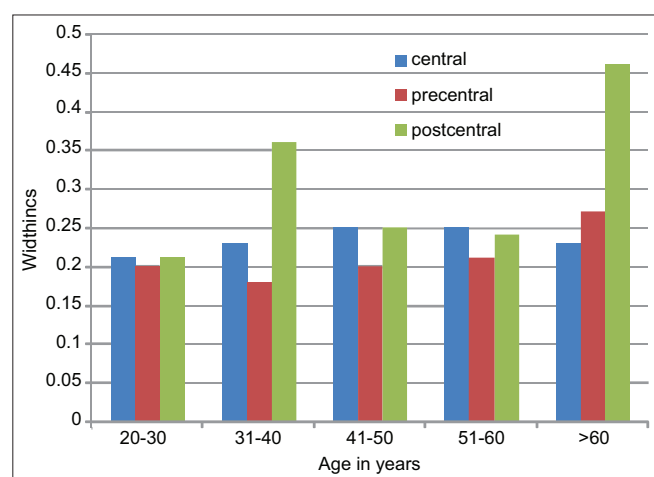


Figure 2: Histogram showing width of the sulci in different age groups

The MRI shows the central, pre-central and post-central sulci, in 20-30 years of age (Image 1) in 31-40 years of age (Image 2), in 41-50 years of age (Image 3), in 51-60 years of age (Image 4) and >60 years of age is shown in Image 5. The MRI inverted window axial section showing the central sulcus is presented in Image 6. Image 7 shows MRI inverted window axial section showing the pre-central and post-central sulci.

DISCUSSION

The purpose of the study undertaken was to demonstrate the age related radiological changes in the major sulci and gyri of the human brain. The observations recorded demonstrated that changes do occur in the dimensions of the sulci and gyri of the brain as age advances.

Table 4: The width of the central sulcus in relation to different age groups

Age group (in years)	Mean (cm)	N	Standard deviation
20-30	.21048	40	.099061
31-40	.23090	40	.087271
41-50	.25082	40	.107774
51-60	.25080	40	.107805
>60	.22980	40	.086572
Total	.23456	200	.098330

Table 5: The width of the pre-central sulcus in relation to different age groups

Age group (in years)	Mean (cm)	N	Standard deviation
20-30	.20400	40	.128288
31-40	.18228	40	.062662
41-50	.20498	40	.064885
51-60	.21310	40	.063430
>60	.26540	40	.068172
Total	.21395	200	.085378

Table 6: The width of the post-central sulcus in relation to different age groups

Age group (in years)	Mean (cm)	N	Standard deviation
20-30	.21418	40	.064027
31-40	.36400	40	.554736
41-50	.25382	40	.064137
51-60	.24475	40	.064881
>60	.46040	40	.073172
Total	.30743	200	.268803

Table 7: The width of the post-central sulcus in relation to different age groups

Age group (in years)	Mean (cm)	N	Standard Deviation
20-30	.21418	40	.064027
31-40	.36400	40	.554736
41-50	.25382	40	.064137
51-60	.24475	40	.064881
>60	.46040	40	.073172
Total	.30743	200	.268803

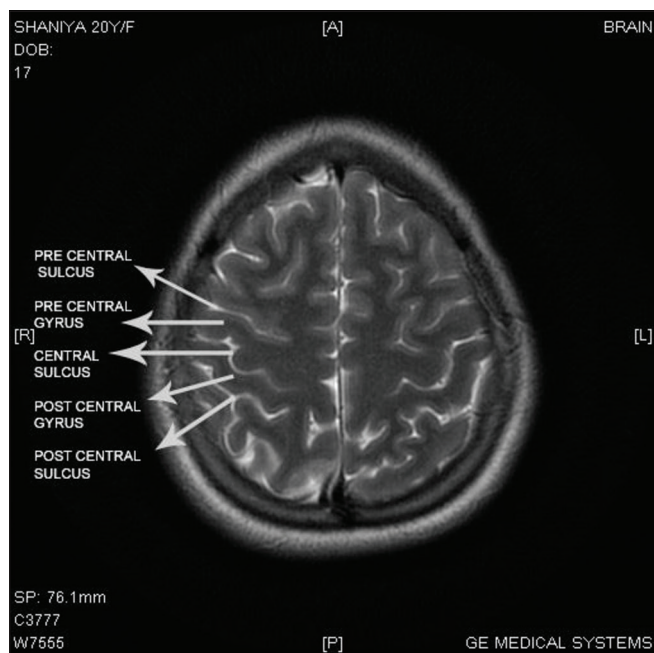


Image 1: MRI showing the central, pre-central and post-central sulci, in 20-30 years of age

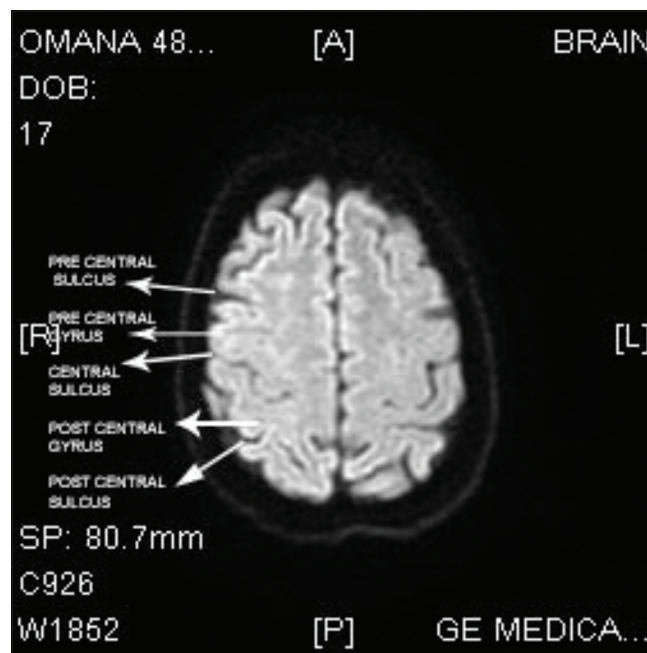


Image 3: MRI showing the central, pre-central and post-central sulci, in 41-50 years of age

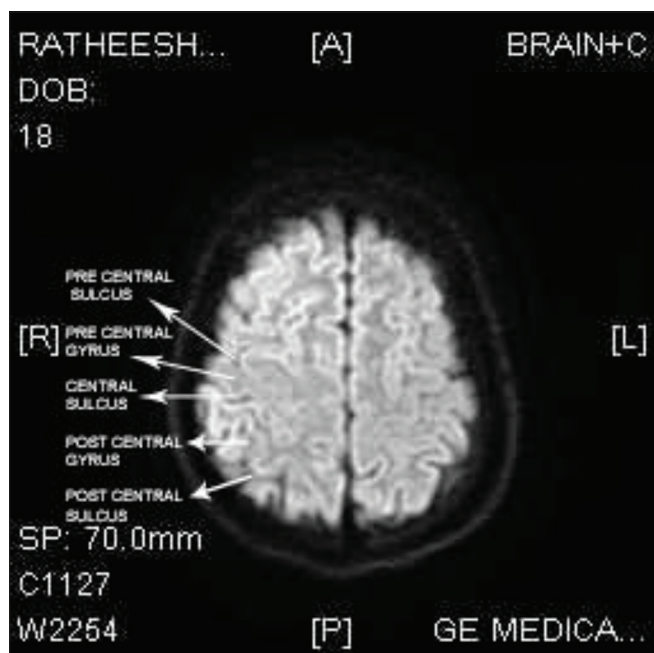


Image 2: MRI showing the central, pre-central and post-central sulci in 31-40 years of age

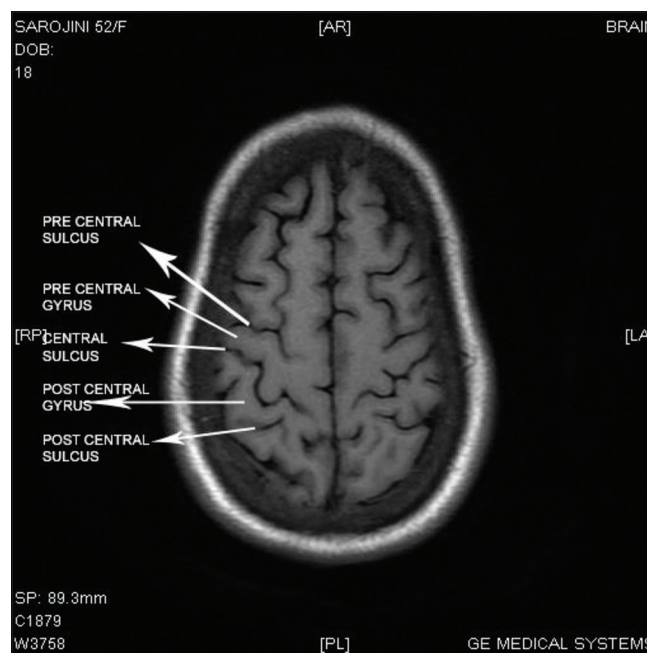


Image 4: MRI showing the central, pre-central and post-central sulci in 51-60 years of age

In 1999 Vincent A. Magnotta, et al⁶ developed a quantitative automated method to achieve in vivo measurement of sulcal and gyral characteristics. This was the first study to examine the age related changes in surface characteristics of the cerebral cortex by using quantitative measures of sulcal and gyral shape.

They found that atrophic gyri have a diminution in their rounded curvature and become more sharply and

steeply curved, giving them a larger (more positive) gyral curvature index. Atrophic sulci, on the other hand, become less curved and more flattened, producing a larger (less negative) sulcal curvature index. These two indices can be considered to provide a quantitative index of the degree of atrophy.⁶

In a cross-sectional study by Coffey C. E, W. E. Wilkinson et al, (1992) seventy-six healthy adults underwent magnetic

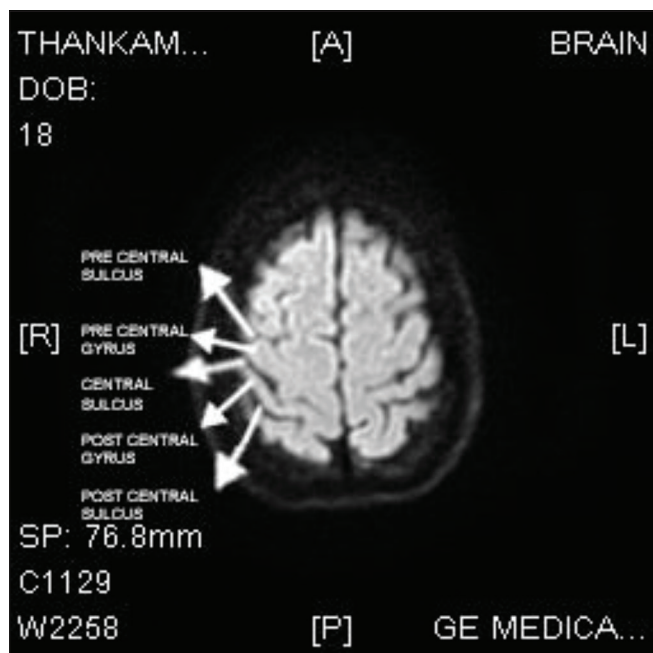


Image 5: MRI showing the central, pre-central and post-central sulci in >60 years of age

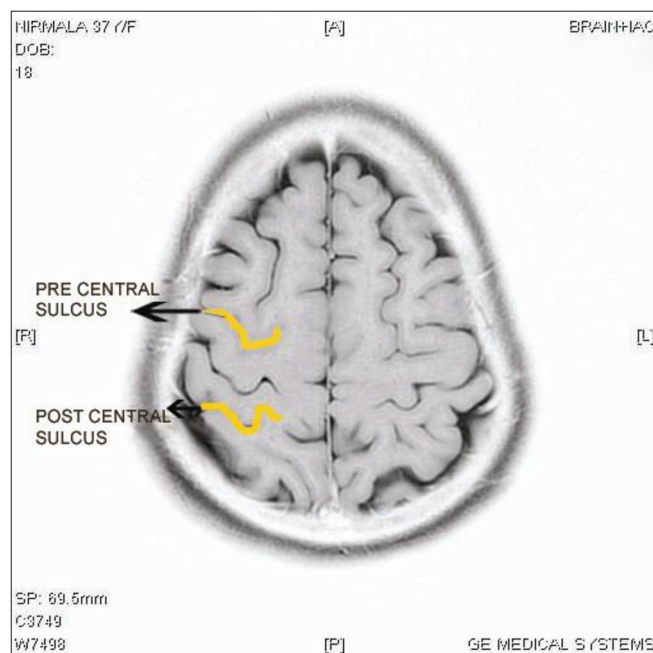


Image 7: MRI Inverted window axial section showing the pre-central and Post-central sulci

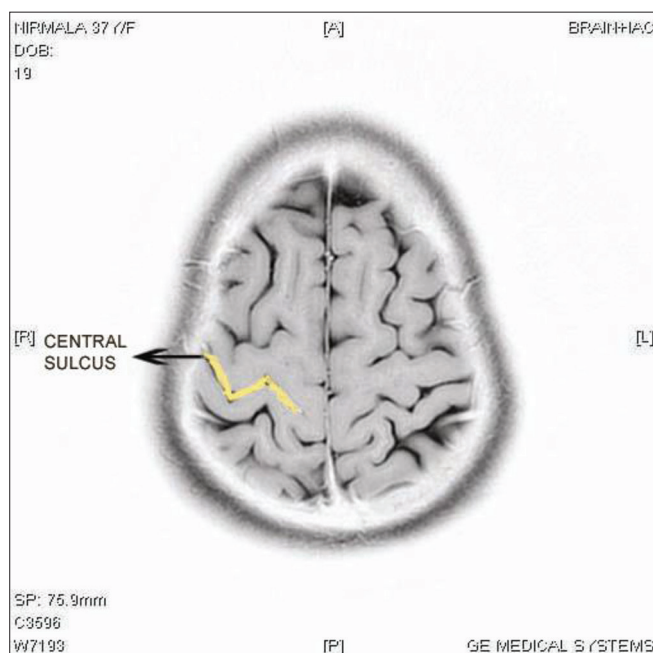


Image 6: MRI Inverted window axial section showing the central sulcus

resonance imaging (1.5 T) to investigate the effects of age on regional cerebral volumes and on the frequency and severity of cortical atrophy, lateral ventricular enlargement, and subcortical hyperintensity. Increasing age was associated with decreasing volumes of the cerebral hemisphere.⁷

Alonso I et al (2010) had measured the depth of the Insula and Sylvian fissure in a standard transventricular axial

plane of the fetal head; the depth of the Parieto-occipital in a plane above and parallel to that used for the insula; and the depth of the Calcarine fissure in a coronal view of the posterior fossa. The depth of these four structures increased with increasing gestational age.⁸

Quantitative measurements of sulci and gyri can potentially provide important information concerning normal brain development and aging as well as a variety of disease processes. It may also be useful in studying the mechanisms of both neuro developmental and neuro degenerative changes that occur during brain maturation and aging.⁶

In the present study, it was found that in case of depth of the sulci, there was decrease in the depth as the age advanced; in case of central, pre-central and post-central sulci. These changes were statistically significant. In case of width of the sulci there was increase in the width of the pre-central and post-central sulci and these changes were statistically significant. There was increase in the width of the central sulcus too, but that was not statistically significant.

The sulcal and gyral patterns reflect brain maturational processes and may indicate the effects of abnormalities in development due to either genetic or environmental factors.

The observations of the undertaken study indicate that age changes do occur in the sulci and gyri of the brain and there is a definite pattern of sequential changes in relation to the different periods of adult life. These changes are due

to the volume loss of the brain due to the cerebral atrophy that occurs during aging.⁹

CONCLUSION

Enhanced interest in diseases and disabilities associated with aging has led to many studies dealing with various changes during the aging process, hoping that methods will be found for delaying the onset, lessening the severity or perhaps preventing some of the pathological changes of aging. In our study, it was found that in case of depth of the sulci, there was decrease in the depth of central, pre-central and post-central sulci as the age advanced. There was increase in the width of the central, pre-central and post-central sulci, as the age advanced

Limitations of the study

The number of study samples can be increased and further studies can be conducted to find out the relation between gender difference and changes of the cerebral cortical sulci and gyri

ACKNOWLEDGMENTS

The authors are grateful to the Department of Anatomy, Medical college, Kottayam

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Authors' contributions:

DA-Concept and design of the study, statistical analysis and interpretation of results, manuscript preparation; **AG**-Co-ordination of the overall study, manuscript editing; **RA**-Reviewed the manuscript preparation; **NG**-Critical revision of the manuscript.

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Sources of Support: None, **Conflict of Interests:** None.