International Journal of Research in Medical Sciences
Edwin M et al. Int J Res Med Sci. 2023 May;11(5):1563-1567
www.msjonline.org
pISSN 2320-6071 | eISSN 2320-6012

DOI: https://dx.doi.org/10.18203/2320-6012.ijrms20231316

Original Research Article

A retrospective observational study on changes in macular thickness with age in normal population using spectral-domain optical coherence tomography

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Received: 20 November 2022
Revised: 12 April 2023
Accepted: 19 April 2023

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ABSTRACT

Background: The aim of this study was to determine the changes in macular thickness with age, by SD-OCT and to estimate the inner and outer retinal layer thickness of outer and inner macula based on different zones and to assess their relationship with age.
Methods: A retrospective observational study of 50 subjects with age ranging from 21 to 60 years was studied with SD-OCT (10 mm scan). The study was done in the month of April 2021 at Department of Ophthalmology, Sree Gokulam Medical College and Research Foundation.
Results: Total macular thickness ranged from 180 to 225 micrometer with no significant change with age. It was found that the thickness of inner retinal layer showed a significant decrease with age in 72% of subjects ($p<0.05$) and changes in outer layer was not significant. The inner retinal nerve fibre layer thickness in all quadrants was more than outer retinal layer thickness. The nerve fibre layer thickness of outer macula was more than the inner macula followed by the fovea. The RNFL was thickest at the inferior quadrant and thinnest at the temporal quadrants, followed by the nasal quadrant and the superior quadrant.
Conclusions: The total macular layer thickness didn't show any significant change with age. It was found that the inner retinal layer thickness showed a significant decrease with age but outer retinal layer didn't. This information can be used for clinical studies evaluating the association between macular thickness and various retinal diseases.

Keywords: Total macular thickness, OCT, Outer retinal thickness, Inner retinal thickness, Fovea, 9 ETDRS regions

INTRODUCTION

Optical coherence tomography (OCT) is the most widely used non-invasive imaging technique currently available for evaluation of ocular structures. OCT offers an objective method of quantitatively determining the macular characteristics and can produce cross-sectional images with high resolution accurately and precisely and is purely non-invasive. It is a micrometer-scale imaging modality that permits cross-sectional imaging of biological tissue microstructure using the principle of Michelson interferometry (tissue backscattering properties).[1] With the advent of spectral-domain OCT technology (SD-OCT) having increased axial resolutions and faster scanning speeds compared to earlier-generation time-domain OCT systems, clinical practice has improved. It is useful for high resolution reproducible in-vivo imaging of the retinal structure; this ocular technology is a useful tool to ophthalmologists. High resolutions in vivo retinal images are essential for diagnosis and follow up of patients with macular oedema and other macular diseases. The changes can be detected early by imaging the macula using an OCT that facilitates both thicknesses and morphology detection before these

changes are clinically evident. Retinal nerve fibre layer thickness is thinnest in temporal quadrant and thickest in superior quadrant. Thinning of retinal and retinal nerve fibre layer (RNFL) occurs with advancing age. *In vivo* techniques like OCT can show thinning of optic nerve RNFL and retina in specific areas and it can be of great clinical utility in diagnosis and monitoring of various retinal diseases.[3]

METHODS

Methodology

After obtaining clearance from ethics committee, in this retrospective observational study, 50 eyes of 50 patients, age ranging from 21 to 60 years were studied with SD-OCT (10 mm scan). The study was done in the month of April 2021 at the Department of Ophthalmology, Sree Gokulam Medical College and Research Foundation, Venjaramoodu. OCT scans performed on the right eye of 50 healthy individuals were taken. Total macular thickness, inner retinal layer thickness (which was measured from internal limiting membrane to external limiting membrane) and outer retinal layer thickness (measured from external limiting membrane to Bruch membrane) were assessed in the region 5 mm temporal to the fovea (perifoveal zone).

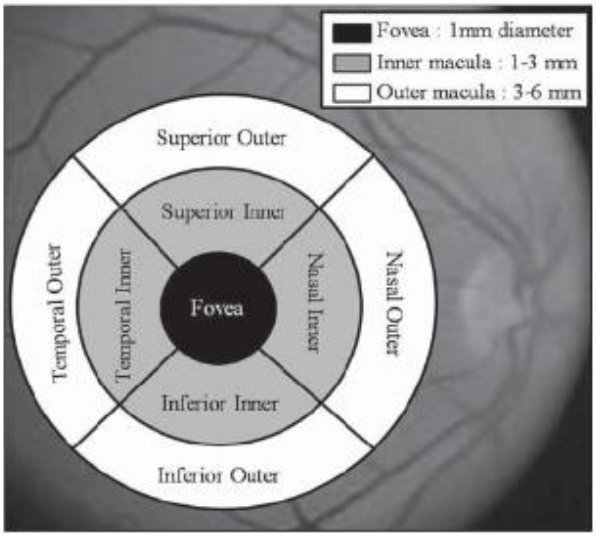

Figure 1: ETDRS regions of the macula as measured by fast macula program of OCT.

Inclusion criteria

Patients with age >21 and <50 years were included.

Exclusion criteria

Patients with age <21 and >50 years and patients with pre existing posterior segment diseases were excluded.

The fast macula thickness map was used, which comprises 3 concentric circles centered at the fovea that divide the macula into 3 zones; zone 1: the fovea (less than 1 mm diameter), zone 2: the inner macula (1 to 3 mm) and zone 3: the outer macula (3 to 6 mm). These zones were further divided into 9 ETDRS (early treatment diabetic retinopathy study) regions (Figure 1).

Data were collected and recorded. For each eye, total retinal layer thickness as well as the thickness of the outer and inner layers of retina were calculated together with their coefficients of variation. Thereafter retinal thickness of outer and inner macula was correlated with age. The correlation of age with retinal layer thickness measurements was determined. The partial correlation test was used to determine the effect of age on individual layer thickness with age and sex as confounders.

RESULTS

This study was conducted on 50 eyes of 50 patients including 36 females (72%) and 14 males (28%), age ranging from 21 to 60 years. The mean (±SD) age was 56.9 (±10.5) years.

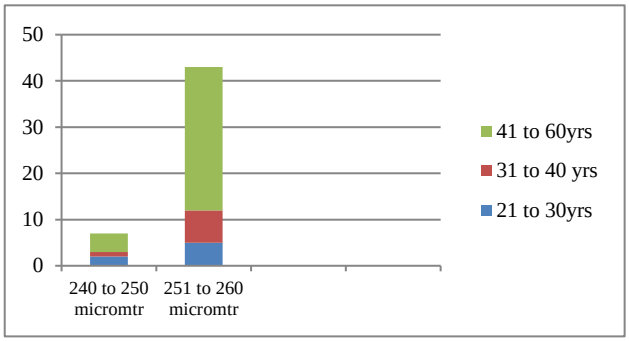

Figure 2: Bar chart showing the association between total macular thickness and age.

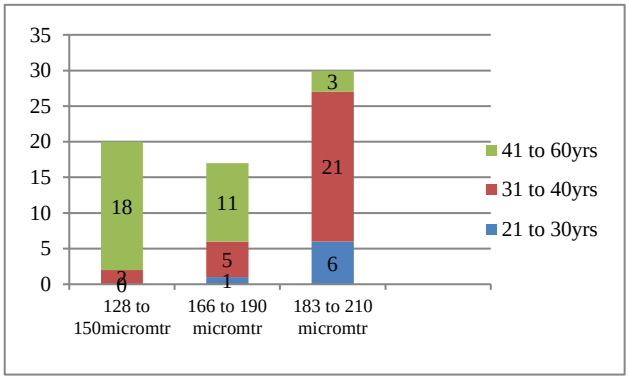

Figure 3: Association between the inner retinal layer thickness and age group.

Majority of patients (42%) were in 41 to 60 years age group.

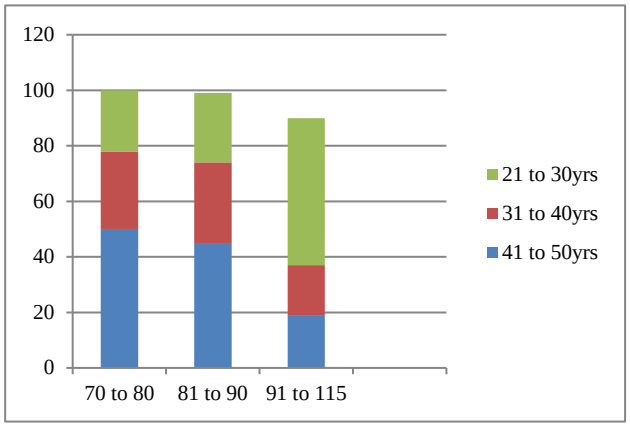

Figure 4: The outer retinal layer thickness and different age groups.

Majority of participants had a total macular thickness ranging from 251 to 260 micrometer with no statistically significant change with age (Figure 2).

The majority of patients' average inner retinal layer thickness in the 21 to 30years age group was 183 to 210 micrometer and in the 41 to 60year age group it was 128 to 150 micrometers. The thickness of inner retinal layer at the macula showed a significant decrease with age in 72% of subjects ($p<0.05$) (Figure 3).

The majority of patients' average outer retinal layer thickness in the 21 to 30years age group was 91 to 115 micrometer and in the 31 to 40year age group it was 81 to 90 micrometer and in the 41 to 50 age group was 70 to 80 micrometers (Figure 4).

Table 1: Retinal nerve fibre layer thickness on different quadrants.

Parameters (µm)	21 to30 years	31 to40 years	41to60 years
Foveal thickness	80.26±20.79	68.34±9.0	65.7
Superior outer macula	141.2 ± 21.7	138.5±5.90	131.8±4
Outer retinal thickness	28.9	26.80-4.5	26.22
Inner retinal thickness	122.50±13.3	124.55±4.4	119.80
Superior inner macula	75.6±9.0	72.09±12	68.77
Outer retinal thickness	20.8±11.1	21.8±5.5	20.9
Inner retinal thickness	60.2 µm	56.05±11.2	50.80
Inferior outer macula	129.1 ± 25.67	126.88	120.99
Outer retina	28.78	26.99	27.33
Inner retina	105.8	100.9	95.88
Inferior inner macula	99.3±115.9	90.84	90.05
Outer retina	18.88	18.65	17.90
Inner retina	82.99	78.9	74.32
Temporal outer macula	104.8 ± 38.81	100.3±11.2	100.5±8.2
Inner retina	100.98	95.90	89.56
Outer retina	15.89	12.99	14.9
Temporal inner macula	61.3±71.2	62.8±2.2	60.6±11.3
Outer retina	15.8	17.99	14.99
Inner retina	55.90	50.9	45.98
Nasal outer macula	66.38 ±17.37	64.33±7.22	60.22
Outer retina	12.9	12.07	14.09
Inner retina	55.89	52.07	50.90
Nasal inner macula	53.0±65.6	53.3±6.1	51.22
Outer retina	10.09	10.99	11.4
Inner retina	49.88	49.5	44.6

No statistically significant change in outer retinal layer thickness was seen with advancing age (Figure 4).

The inner retinal nerve fibre layer thickness in all quadrants are more than outer retinal layer thickness. The nerve fibre layer thickness of outer macula is more than the inner macula followed by the fovea. The RNFL is thickest at the inferior quadrant and thinnest at the temporal quadrants, followed by the nasal quadrant and the superior quadrant. The Mean foveal thickness measured 80.26±20.79 µm in 21 to 30 years, 68.34±9.0 µm in 31 to 40 years and 65.7 µm in 41 to 50 years age. It was statistically significant change with age. The retinal nerve fibre layer thickness is more in zone 3 than in zone 2 followed by zone 1.

DISCUSSION

In our study we measured the total retinal layer thickness, inner and outer retinal layer thickness and evaluated the effect of age on individual retinal layer thickness and the mean macular thickness was found to be 268 micrometer and there was no statistically significant correlation with advancing age. This was similar to the result obtained in a study by Adhi et al which showed a mean macular thickness of 262.80±13.342 µm and no association with age in healthy eyes.[1] Wang et al showed that the association between decreasing thickness of most retinal layers with older age and the diagnosis and follow-up of retinal diseases may be improved if the thickness of the various retinal layers, in addition to the total retinal thickness, was taken into account.[2] In our study the macular thickness showed no statistically significant change with age which is at odds with studies conducted by Kamal et al, Nieves et al and Alamouti et al which showed a negative correlation of macular thickness with age.[3-5] Nieves et al showed that the retinal thickness was reduced by 0.24 µm for every one year of age.[4]

Out of the 50 eyes studied it was found that the thickness of inner retinal layer showed a significant decrease with age in 72% of subjects ($p<0.05$). This finding was similar to another study done by Nazik et al which showed a negative correlation of inner retinal layer thickness with increasing age and this should be taken into consideration while interpreting retinal layer and RNFL thickness data in studies concerned with the effects of disease on the retina.[6] These age-related changes in the inner retinal layers may be of use as an objective parameter for age related retinal diseases or normal ageing in general. Park et al also found significant differences in thickness and volume of the retinal layer with age in a healthy population.[7] When inner retinal thickness was compared between 30 years of age and 60 years of age, it was significantly thicker in the younger age group than in the older age group, similar to the results obtained in our study. The GCL and their axons (RNFL) are particularly prone to loss with age. In our study the outer retinal layer thickness in the perifoveal zone showed no statistically significant change with age whereas in a study by Rao et al the thickness of RPE-OS showed a statistically significant negative correlation with age in the perifoveal zone.[8] A previous study by Parikh et al revealed Chi-square test results which showed a significant inverse relationship between age and RNFLT.[9] It also showed that the loss was not uniform in all the quadrants, with maximum loss in the superior quadrant, and seemed to reach a maximum after the age of 50 years. Furthermore, it seemed that inferior quadrant RNFL was more resistant to loss. Study by Jacqueinechua et al showed that the thickness of individual retinal layers varies by age.[10] Most of the retinal layers decreased with age. They also found the influence of gender, ethnicity and axial length on specific retinal layers to be sectoral-specific Satana et al.[11] Specifically, in the superior quadrant, the average RNFL thickness was 141.2±21.7 µm in those aged 21 to 30 years, 138.5-5.90 µm in those aged between 31 and 40 years, and 131.84± 11.2 µm in those aged between 41 and 60 years. In the inferior half, the average RNFL thickness was 104.60±9.90 µm in those aged less than 70 years, 103.39±13.16 µm in those aged between 70 and 79 years, and 95.88±13.78 µm in those aged between 80 and 89 years. Schuman et al showed sectoral p-RNFL was the thickest in the inferior temporal region (155.12±19.42 µm, range 68 to 271 µm), followed by the superior temporal region (154.67±19.99 µm, range 32 to 177 µm).[12] The mean global p-RNFL thickness was 106.60±9.41 µm (range: 72 to 171 µm) in the right eyes, 105.99±9.30 µm (range: 76 to 163 µm) in the left eyes, and 106.29±9.36 µm (range: 72 to 171 µm) across both eyes. Age was positively correlated with p-RNFL.

Bluementhal et al showed RNFL was thickest in the inferior quadrant, followed by the superior quadrant, nasal quadrant, and temporal quadrant and followed the ISNT rule. Age was observed to have a negative correlation with all RNFL parameters. RNFL was observed to decline gradually as age increases.[13]

Katiyar et al reported positive correlation between nasal and inferior quadrants of the outer macula with age while negative correlation between superior and temporal quadrants of the outer macula with age with a 0.25 µm reduction in mean RNFL thickness per year of aging.[14]

Limitations

The limitations were small sample size and other factors affecting the retinal layer thickness was not included.

CONCLUSION

We found that the inner retinal layer thickness showed a significant decrease with advancing age but outer retinal layer and total macular thickness didn't show any statistically significant change with age. The retinal nerve fibre layer thickness was maximum at the inferior quadrant and thinnest in the temporal quadrant. This information can be used for clinical studies evaluating the association between total macular thickness and age related diseases. Measurement of retinal layer thickness is important in the diagnosis and monitoring of retinal and optic nerve diseases, and to distinguish disease processes from normal age-related changes. Hence it is important to know the effect of aging on OCT measurements of the retina. Detecting the normal value of the macular retinal thickness in normal population helps in early diagnosis of retinal diseases. Currently clinical studies on thickness of various retinal layers in normal healthy population, and the effect of age, sex, as well as the refractive error are very minimal. The major limitation of this study was that no clinical evaluation could be done.

Funding: No funding sources
Conflict of interest: None declared

Ethical approval: The study was approved by the Institutional Ethics Committee

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Cite this article as: Edwin M, Raghavan R, Mahadevan K. A retrospective observational study on changes in macular thickness with age in normal population using spectral-domain optical coherence tomography. Int J Res Med Sci 2023;11:1563-7.