ORIGINAL ARTICLE

Retinal Thickness Evaluation in Healthy Eyes from North-West Punjab Through Optical Coherence Tomography

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ABSTRACT

Objective: To determine the mean retinal thickness in healthy eyes from north-west Punjab through commercially available optical coherence tomography (OCT) mapping software, version 3.0, from the Stratus OCT (OCT3).

Study Design: Descriptive study.

Place and Duration of Study: Al-Shifa Trust Eye Hospital, Rawalpindi, from August 2008 to February 2009.

Methodology: One hundred and two eyes of 75 healthy north-west Punjabis, fulfilling inclusion criteria were enrolled from OPD of Al-Shifa Trust Eye Hospital. After informed consent, demographic detail was taken. Best-corrected Snellen visual acuity was recorded. OCT was performed by using Stratus Carl Zeiss OCT through dilated pupil by an experienced operator. The retinal thickness was divided into 9 sections and displayed as three concentric circles including a central circle at fovea (1 mm), an inner ring (3 mm) and an outer ring (6 mm), each ring being divided into four quadrants. OCT parameters of macular thickness were analysed with baseline variables including age, gender and best corrected visual acuity.

Results: The mean central foveal thickness (at foveola) was 166.30 ± 24.95 µm while the mean foveal thickness (in central 1000 microns) was 194.89±21.33 µm. There was no correlation between macular thickness and either age (r=0.109, p=0.275) or gender (Eta=0.128) or best corrected visual acuity (Eta=0.234).

Conclusion: Reference values were determined for mean retinal thickness in healthy eyes from north-west Punjab through OCT. These measurements were upto 54-µm higher and upto 29 µm lower than some previously reported healthy retinal thickness values. Therefore, normative database should be determined for the population under study based on regional and ethnic differences.

Key words: *Retinal thickness. Optical coherence tomography. Ethnicity. North-west Punjab.*

INTRODUCTION

Healthy retina is one of the most pivotal pre-requisites for normal visual acuity. Macular diseases, particularly diabetic retinopathy and retinal venous occlusive disorders are important causes of visual loss and blindness. Many of these, especially diabetic macular edema, if recognized and treated timely, can reduce the risk of visual loss.[1] High resolution and reproducible measurement of the macular thickness, are of utmost importance for management of macular diseases.[2-8] Optical coherence tomography (OCT) is a promising diagnostic tool for quantitative imaging of the retina. OCT is a non-contact, non-invasive modality for high-resolution cross-sectional images of retina.[3,9] Optically, it utilizes near infrared low coherent light to obtain two-dimensional images of the retina and optic nerve head.

Since 2002, when Stratus OCT was made commercially available, various clinical trials have been conducted to see the macular thickness in normal healthy population. Macular thickness measurement for diagnostic function may differ with the ethnicity of the population used as a database.[2] Most of the studies conducted internationally, either utilized earlier versions of OCT,[3-7] or had very small sample size.[8] Thus, it is desirable to develop the normative reference values for populations being studied. Normative database will also be useful in interpreting and further management of pathological features of the macula.

Quantitative normative database for retinal thickness using OCT will be useful in early detection and management of macular oedema especially of diabetic origin. It may also help to select a specific mode of treatment for diabetic macular oedema. To the best of our knowledge, there is no reported normative database for macular thickness measurement by OCT-3 system in normal north-west Punjabi eyes (people originating in Rawalpindi, Attock and Jhelum districts).[10] This research was carried out to establish the normal retinal thickness using OCT-3 in north-west Punjabi eyes, and to see if any differences in retinal thickness exist according to the ethnicity.

METHODOLOGY

This study was performed in Al-Shifa Trust Eye Hospital, Rawalpindi, from August 2008 to February 2009. North-

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west Punjabi origin patients, confirmed from their National Identity Cards, were enrolled from the out patient department. An informed consent was taken. All patients underwent a complete ophthalmic examination which included personal and family history, general physical examination, best-corrected visual acuity tested with Snellen visual acuity charts, applanation tonometry and slit lamp biomicroscopy.

Exclusion criteria included any history of ocular surgery done less than one year ago or laser therapy, trauma to eye or any other pathology like glaucoma, systemic problems like Diabetes, hypertension, renal failure that are known to affect the eye, best-corrected visual acuity worse than 6/18, and refractive error greater than -3/+3.

Optical coherence tomograms were acquired through a dilated pupil by an experienced operator using the OCT-3 (Carl Zeiss Ophthalmic Systems, Inc, Humphrey Division, Dublin). After recording demographic profile, pupils were dilated. The macular thickness map scan protocol on the OCT-3 was used to obtain six consecutive macular scans, 6 mm in length, centered on the fovea, at equally spaced angular orientations.

The measurement of retinal thickness at selected points on the tomographs was obtained automatically by means of a computer algorithm of OCT-3, which assumes that the first highly reflective band corresponds to the vitreoretinal interface and the second corresponds to the retinal pigment epithelium. Retinal thickness measurement was made by determining the displacement between anterior surfaces of these two interfaces. The retinal thickness volume tabular analysis protocol was used in this study. This protocol provides the retinal thickness and volume data table, which includes thickness and volume quadrants, averages, and ratio among the quadrants as defined by the Early Treatment Diabetic Retinopathy Study.[11] Foveal thickness was defined as the average thickness in the central 1000-m diameter of the Early Treatment Diabetic Retinopathy Study layout.[11] Central foveal thickness was defined as the mean thickness at the point of intersection of the six radial scans.

Each optical coherence tomograph was evaluated to be of adequate quality for submission. Data was analyzed on Statistical Package for Social Sciences (SPSS) version 10.0. Mean ± SD was calculated for age and retinal thickness in different quadrants. Frequency as percentage was presented for gender. Unpaired sample t-test was used to compare retinal thickness in different quadrants. A $p \leq 0.05$ was considered significant. Pearson's correlation coefficient was calculated to assess relationship between foveal thickness and age. Eta correlations were calculated to see the correlation between the foveal thickness and the gender and visual acuity of participants.

RESULTS

One hundred and two eyes were included in this study, among which 52.9% (54 eyes) were right and 47.1% (48 eyes) were left. Study population comprised of 49% (50 eyes) females and 51% (52 eyes) males. Mean age of study population was 49.64 years (minimum 18 years, maximum 73 years). About 7.8% (8 eyes) of study population were between 15-25 years of age, 7.8% (8 eyes) were between 26-35 years, 12.7% (13 eyes) were between 36-45 years, 33.3% (34 eyes) between 46-55 years, 30.4% (31 eyes) between 56-65 years and rest 7.8% (8 eyes) were between 66-75 years of age. The visual acuity was recorded as Snellen acuity of 6/6 in 52% (53 eyes), 6/9 in 24.5% (25 eyes), 6/12 in 15.7% (16 eyes) and 6/18 in 7.8% (8 eyes) of the study population.

The mean central foveal thickness at fovea was 166.30 ± 24.95 µm while the mean average foveal thickness was 194.89 ± 21.33 µm. The mean age of study population and distribution of retinal thickness in different quadrants is given in Table I. The comparison between mean macular thickness in different quadrants through unpaired t-test is given in Table II. The superior (mean=284.5 µm) and nasal (mean = 245.6 µm) quadrants were thickest overall. The retinal thickness was least in temporal quadrant (mean = 235.8 µm). There was no correlation between macular thickness/ foveal thickness and either age (r=0.109, p=0.275) or gender (Eta=0.128) and best corrected visual acuity (Eta=0.234).

Table I: Mean age and retinal thickness in various quadrants in study population.

Variables	N	Minimum	Maximum	Mean	Std. deviation
Age	102	18	73	49.64	12.93
Foveal thickness	102	132	244	194.89	21.33
Temporal inner macular thickness	102	159	279	251.46	19.47
Superior inner macular thickness	102	187	291	262.70	18.29
Nasal inner macular thickness	102	179	297	260.35	22.70
Inferior inner macular thickness	102	199	299	265.23	17.44
Temporal outer macular thickness	102	153	272	218.91	18.47
Superior outer macular thickness	102	200	265	234.39	13.35
Nasal outer macular thickness	102	152	281	244.49	24.96
Inferior outer macular thickness	102	178	281	225.97	18.92
Fovea minimal	102	110	228	166.30	24.95

Table II: Comparison of mean macular thickness in different quadrants through unpaired t-test.

Macular quadrants compared	No. of eyes (n)	p-value	t-value
Superior inner macular thickness and inferior inner macular thickness	102	0.3128	1.0119
Temporal inner macular thickness and nasal inner macular thickness	102	0.0043	2.8843
Superior outer macular thickness and inferior outer macular thickness	102	0.0003	3.6704
Temporal outer macular thickness and nasal outer macular thickness	102	< 0.0001	8.3331

Table III: Reference values for macular thickness in healthy eyes used/ given in various international studies.

Author	No. of eyes (n)	Mean foveal thickness
Massin *et al.*[4]	60	170+/-18 microns
Goebel *et al.*[6]	60	153 +/- 15 microns
Lattanzio *et al.*[8]	50	161.9 +/- 12.9 microns
Alkuraya *et al.*[16]	40	191.2 ± 21.96 µm
Browning *et al.*[17]	100	208+/-22 microns
Konno *et al.*[18]	24	155.1 +/- 14.9 microns
Larsen *et al.*[19]	14	237 +/- 15 microns
Polito *et al.*[20]	10	223±14 microns
Gobel *et al.*[21]	205	142 +/- 18 microns.
Pierre-Kahn *et al.*[22]	17	191.4 (17.6) microns

DISCUSSION

Retinal thickness evaluation has a key role in the timely diagnosis and management of a number of retinal vascular disorders. This objective has been revolutionized with the advent of optical coherence tomography. OCT not only renders cross-sectional images of retina with micrometer resolution but also gives quantitative analysis of retinal quadrants. Thus, diagnosis of macular oedema and monitoring of response to various treatments has become possible. Moreover, it is free from interobserver variability and is reproducible.

Since, the advent of OCT two decades ago, various studies have been conducted internationally to see its role in various clinical scenarios involving macular disorders and optic nerve pathologies. However, most of them lack a normative data for the population under study. The retinal thickness may vary according to the racial differences,[2,12] which tends to confound the interpretation of results. Keeping these facts in mind, this study was conducted to determine the normative database in healthy north-west Punjabi eyes.

A number of international studies conclude that ethnic and regional differences in retinal thickness do exist and should be investigated. Sanchez-Tocino *et al.* evaluated the retinal thickness in healthy and diabetic Spanish patients.[7] The mean foveal thickness was 145.1±15.8 µm and never exceeded 180 µm in any of the normal eyes. The mean foveal thickness according to this study was approximately 50 µm higher. In addition, they also found that temporal area was the thinnest in relation to nasal, superior, and inferior areas (p ± 0.001). There was no significant correlation between age and foveal thickness in each one of the groups. The temporal area was thinnest.[7] The results of this study corroborate these additional findings.

Kelty *et al*. found that mean foveal thickness (MFT) for Caucasians was 32 µm greater than for African Americans (217 vs. 185 µm, respectively; p < 0.001).[12] While according to the present research, the retinal thickness was 9 µm higher as compared to Caucasians and 23 µm lower than in African Americans. Kelty *et al*. suggested that biochemical and histologic studies should be carried out to determine the reason for this racial difference in retinal thickness.[12]

Varma *et al*. conducted a similar study in Latinos.[13] In their study, the mean age of the participants was 52 years. The average macular retinal thickness was 173 ± 28.5 µm, which was 21 µm higher than our results. They also found that there were no gender-related differences in macular or perimacular areas.[13] The average macular and peripapillary retinal nerve fibre layer (RNFL) thickness was thinner in older Latinos than in younger Latinos. They concluded that regional and age-related differences in the macular thickness should be considered when diagnosing and monitoring individuals with diseases that affect the RNFL.[13]

Chan *et al*. reported in their study that the mean foveal thickness (average thickness in the central 1000-µm diameter area) was 212 ± 20 µm, approximately 38-62 µm thicker than previously reported values.[14] It was hypothesized that this discrepancy might have been the direct result of the higher resolution and faster scanning time associated with the newer version of OCT.[14] Although this study is helpful in determining normal macular thickness measurements, using the OCT-3 software, there is no mention of racial or gender differences. This results are 18 µm lower than their reported values.

There are further studies that report healthy macular thickness (mostly mean foveal thickness), as given in Table III. However, the reported values range from as low as 139 µm,[15] to as high as 223 microns.[4,6,8,16-22] These values gain importance when they are used to describe the cut off limits to differentiate normal from abnormal maculas. This is especially worth considering when determining a criterion for the early detection of diabetic macular oedema.

It is hard to determine the etiology of these significant variations without specific histological or biochemical studies. However, Chauhan *et al*. hypothesized that

variable amount of melanin in retinal pigment epithelium can be one factor.[23] They postulated that with more melanin there is greater scattering and hence less reflected signals reaching the OCT machine. This leads to falsely low interpretation of macular thickness. This can also be attributed to racial and ethnic factors.

Thus keeping the above discussed discrepancies in retinal thickness in consideration it is suggested that a normative databased should be developed based on ethnic and regional basis, for every population under study especially when defining cut off values for macular pathologies like diabetic macular oedema. It is also recommended that biochemical and histologic studies should be carried out to determine the reason for racial differences in retinal thickness. Similar studies should be carried out in other regional centres in Pakistan as this study only included north-west Punjabi subjects which is, therefore, limitation of this study.

CONCLUSION

The normative database should be determined for the population under study. We determined the reference value for healthy retinal thickness in north-west Punjabi eyes through optical coherence tomography. This is expected to be helpful in further research in the diseases of macula in the region.

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