

Original Research Article

To study the correlation of mean macular thickness using optical coherence tomography with distant and near visual acuity in patients of diabetic maculopathy

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ABSTRACT

Background: To study the correlation of mean macular thickness using optical coherence tomography with distant and near visual acuity in patients of diabetic maculopathy.

Methods: A prospective, single centre study was conducted on 50 eyes of diabetic patients, with Diabetic Retinopathy with CSME in which patients macular thickness was measured on Ocular Coherence Tomography using fast macular thickness scan. The unaided and best corrected visual acuity was measured in all patients using Snellens distant vision and Jagers near vision charts.

Results: A linear correlation between the OCT measured macular thickness and both the distance visual acuity and the near visual acuity. That means that for a given level of macular thickness, we can predict visual acuity for it. In our series correlation coefficient was 0.921 for distance visual acuity and 0.899 for near visual acuity. Although the correlation value is high in our study, we did find a range of visual acuities for a given range of macular thickness. For every 100 micron change in mean macular thickness, best corrected visual acuity (BCVA) changed 0.3 LogMAR units, for distance as well as for near.

Conclusions: Macular thickness and visual acuities (distance as well as near) are strongly correlated but there can be variations. And a wide range of visual acuities is possible for a given degree of macular edema. Macular thickness though a strong predictor of visual acuity; other factors might also play a role in determining visual acuity for a particular patient.

Keywords: Diabetic maculopathy, Macular thickness, Optical coherence tomography

INTRODUCTION

Diabetes is a leading cause of visual loss in industrial world.¹ A population based study on an urban population in South India has shown a prevalence of diabetes of nearly 5% in those aged 20 years or more.²

In India, the prevalence of type 2 diabetes mellitus from different regions of the country is estimated to vary from 5 to 14 percent. In 2000 AD, nearly 31 million people in

India had diabetes and this number is likely to increase to 79 million by 2030 AD.³ Thus India apparently is the Diabetes Capital of the world and is likely to remain so for the next 30 years.⁴

If the patient is asymptomatic, then two plasma glucose values are mandatory to establish the diagnosis of diabetes preferably including one fasting plasma glucose level.⁵ Diabetes is one of the leading causes of blindness in the Western countries.⁶

Diabetic maculopathy

Diabetic retinopathy situated in and around the macula is described as diabetic maculopathy, which can result in significant visual impairment. Macular edema is the most common cause of moderate visual loss (defined as visual acuity loss equivalent to a doubling of visual angle) in non-proliferative diabetic retinopathy.⁷ This decreased vision is caused by an increase in extracellular fluid within the retina distorting the retinal architecture and frequently taking on a pattern of cystoid macular edema. This fluid accumulates within the retina because of the breakdown of the barriers within the retinal blood vessels and possibly the retinal pigment epithelium

Basic concepts of optical coherence tomography (OCT)

Retina is a multilayered tissue with each layer having a different reflectance pattern. This permits recognition of its different layers. OCT is one diagnostic imaging technique that enables such recognition of the multiple retinal layers in vivo, in a noninvasive manner. Optical Coherence Tomography (OCT) allows good assessment of retinal diseases and provides greater understanding of pathology and correlation between structure and function.

Although fluorescein angiography is highly sensitive for the qualitative detection of fluid leakage which causes macular edema, measurement of retinal thickness may correlate better with areas of retinal dysfunction than does the amount of fluorescein leakage. Optical Coherence Tomography (OCT) enables the clinician to show accurately sub clinical retinal changes in the absence of clinically significant macular edema (CSME).⁸

The aim of our study was to assess a correlation between the degrees of macular edema as measured by Optical Coherence Tomography (Cirrus™ HD-OCT Spectral Domain technology, Figure 6) with the severity of retinal dysfunction as measured by visual acuity in patients of Diabetic Macular Edema.

METHODS

This prospective study will include 50 eyes of diabetic patients with diabetic retinopathy with CSME attending the ophthalmology OPD of MMIMSR.

Inclusion criteria

- Diabetic patients with CSME as documented by slit lamp biomicroscopy.

Exclusion criteria

- Hazy ocular media that may preclude good clinical examination, Optical Coherence Tomography (OCT) imaging, slit lamp biomicroscopy like vitreous hemorrhage, cataract, corneal opacity, iridocyclitis etc.
- High myopia >6 diopter.

- Pseudophakia.
- Debilitating systemic illness.
- Prior laser treatment for diabetic macular edema or proliferative retinopathy.
- History of glaucoma.
- Any other macular pathology like macular dystrophy, macular degeneration, or macular hole.

A detailed history was recorded for all patients including history of duration of diabetes, drugs that they have received in the past and the drugs that they are currently using, history of hypertension, its duration and treatment received. All patients underwent detailed ocular examination, including:

- Best corrected distant visual acuity using Snellens chart.
- Best corrected near visual acuity using Jaegers chart.
- Intraocular pressure measurement using applanation tonometry.
- Slit lamp examination, and fundus examination with +90 D.
- Optical Coherence Tomography (Cirrus™ HD-OCT Spectral Domain technology).

The unaided and best corrected visual acuity was measured in all patients using Snellen distant vision and Jaeger/N near vision charts. For Snellen distance acuity measurement, Snellen charts were used at 6 meter distance on an illumination box. Unaided visual acuity was measured by occluding alternate eye. This was done in a dark room. Similarly, near visual acuity was measured on Jaegers/ N charts, held at 33 centimeters. Refraction was done for distance and near to record the best corrected visual acuities for distance and near.

Technique of OCT

Measurements of retinal thickness at selected points on the tomography are obtained automatically by means of a computer algorithm, which assumes that the first highly reflective band corresponds to the vitreoretinal interface and the second corresponds to the retinal pigment epithelium. Thus, evaluating the displacement between anterior surfaces of these two interfaces determines retinal thickness.

Macular thickness and volume map is divided into nine sections and displayed as three concentric circles including a central circle corresponding to central macular thickness, an inner ring and an outer ring with a diameter of 1mm, 3mm, and 6mm respectively and each ring is divided into four quadrants i.e. inner superior, inner nasal, inner inferior, inner temporal, outer superior, outer nasal, outer inferior, outer temporal.

Fast macular thickness scan obtains 6 scans of 6 mm length rapidly within 2 seconds and allows comparative thickness/volume analysis. Which depicts both thickness

and volume values using two color coded maps and two numeric maps.

The speed of the Cirrus HD-OCT not only contributes to practice efficiency, it also gives the system its ability to capture a high-density cube of data. In general, I prefer reviewing OCT results in real-time via a live connection and computer monitor. Many physicians, however, prefer to work from the printout. Cirrus HD-OCT printouts display the most clinically relevant data in images and maps.

Procedure

The patient was informed about the procedure. It was explained that it is a completely non-invasive procedure and will require his cooperation for a few minutes.

The patient was seated comfortably in front of the OCT machine with chin positioned in the chin rest. He/she was asked to fixate on the fixation target. The internal fixation (green colour light) target was the commonly used fixation target. Those patients who were unable to fixate with macula were made to fixate with the other eye on an external target. After fixation the fast-macular thickness scan was done on the eye and instrument was so aligned that fundus image and scan beam were displayed on the screen.

Table 3: Mean, median and standard deviation of age of patients.

Minimum age	Maximum age	Range	Mean	Median	Stand. deviation
25	59	25-59	48.82	51.50	8.537

The mean age of patients was 48.82 years, ranging from 22 to 59 year. Median was 51.50 and 8.537 was the standard deviation.

Table 4: Right vs left eye.

	No. of eyes	%
Right	32	64
Left	18	36

There were 32 right eyes out of total 50 eyes comprising of 64% of the total study population. Similarly, there were 18 left eyes out of 50 comprising of 36% of the total population.

Table 5: NPDR vs PDR.

	No. of eyes	%
NPDR	37	74
PDR	13	26

There were 37 eyes out of total of 50 eyes included in the study, which had non proliferative diabetic retinopathy

RESULTS

50 eyes of 50 diabetic patients with diabetic macular edema attending the Out Patient Dept of Ophthalmology MMIMSR, Mullana, Ambala were included in the study.

Table 1: Sex distribution of study population.

Sex	No. of patients	%
Females	22	44
Males	28	56

Out of total of 50 patients, 22 were females and 28 were males, accounting for 44 % and 56 % of the study group respectively.

Table 2: Age distribution of patients in the study.

	No. of patients	%
≤40	9	18
41-50	15	30
51-60	26	52
Total	50	100

Out of total 50 patients, maximum number of patients was from age group 51-60, that was, 26 accounting for 52% of the whole study group.

(NPDR) with CSME; comprising 74% of the total study population, Similarly 13 eyes out of total of 50 eyes had proliferative diabetic retinopathy PDR with CSME, comprising 26% of the total study population.

Table 6: Log MAR BCVA for distance.

BCVA (distance)	No. of eyes	%	Mean
0.2	14	28	0.438
0.3	14	28	
0.5	9	18	
0.6	6	12	
0.8	1	2	
1	6	12	

In Log MAR, BCVA ranged from 0.2 to 1, with mean of 0.438. 14 eyes had BCVA of 6/9 (Log MAR visual acuity of 0.2), 14 eyes had BCVA of 6/12 (Log MAR visual acuity of 0.3), 9 eyes had BCVA of 6/18 (Log MAR visual acuity of 0.5), 6 eyes had BCVA of 6/24 (Log MAR visual acuity of 0.6), 1 eye had BCVA of 6/36 (Log MAR visual acuity of 0.8) and 6 eyes had BCVA of 6/60 (Log MAR visual acuity of 1).

Table 7: Log MAR BCVA for near.

BCVA (Near)	No. of eyes	%	Mean
0.1	11	22	0.404
0.2	11	22	
0.3	3	6	
0.4	10	20	
0.6	6	12	
0.7	2	4	
1	7	14	

In Log MAR, BCVA ranged from 0.1 to 1, with mean of 0.404. 11 eyes had BCVA of N6 (Log MAR visual acuity of 0.1), 11 eyes had BCVA of N8 (Log MAR visual acuity of 0.2), 3 eyes had BCVA of N10 (Log MAR visual acuity of 0.3), 10 eyes had BCVA of N12 (Log MAR visual acuity of 0.4), 6 eyes had BCVA of N18 (Log MAR visual acuity of 0.6), 2 eyes had BCVA of N24 (Log MAR visual acuity of 0.7) and 7 eyes had BCVA of N36 (Log MAR visual acuity of 1).

Table 8: OCT measured mean macular thickness.

Minimum value (microns)	Maximum value (microns)	Range	Mean	Stand. deviation	Median
163	480	163-480	255.16	85.256	217.50

OCT measured mean macular thickness ranged from 163 microns to 480 microns with mean of 255.16 microns.

Note: For analysis of correlation between BCVA and mean macular thickness, BCVA was converted into Log MAR scale and then analyzed.

Table 9: Mean Log MAR BCVA (distance) in different groups.

OCT mean macular thickness	LogMAR distance BCVA					
	N	Mean	SD	Min.	Max.	Median
<200	18	0.222	0.0438	0.2	0.3	0.2
200-299	19	0.405	0.118	0.3	0.6	0.3
300-399	8	0.65	0.169	0.5	1	0.6
>400	5	1	0	1	1	1
total	50	0.438	0.2586	0.2	1	0.3

Table 10: Mean LogMAR BCVA (near) in different groups.

OCT mean macular thickness	LogMAR near BCVA					
	N	Mean	Std. deviation	Median	Min.	Max.
<200	18	0.150	0.0707	0.100	0.1	0.3
200-299	19	0.379	0.1584	0.400	0.2	0.7
300-399	8	0.662	0.2326	0.600	0.4	1.0
≥400	5	1.000	0.0000	1.000	1.0	1.0
Total	50	0.404	0.2996	0.350	0.1	1.0

DISCUSSION

Diabetes Mellitus is a chronic disease characterized by deficiency or ineffective utilization of insulin that leads to persistent hyperglycemia which in turn damages end organs, primarily blood vessels and nerves. It might be appropriate to designate it as a "vasculitis" that result in long term complications leading to increased morbidity and mortality.⁴

Diabetes leads to progressive damage to retinal blood vessels resulting in diabetic retinopathy that makes nearly

2% of the affected people blind and 10% visually handicapped.

Macular edema is the most common cause of moderate visual loss in diabetics.⁷ Blurred vision with inability to read constitutes the main symptom of diabetic macular edema. Areas of focal leakage from micro aneurysms and dilated capillaries segments characterize focal macular edema. Diffuse edema results from breakdown of blood retinal barrier with leakage from micro aneurysms and dilated capillary bed through-out the posterior retina. The diagnosis of diabetic macular edema depends on the slit-

lamp examination and fluorescein angiography. Moreover, these traditional methods including slit lamp biomicroscopy and stereo fundus photography are relatively insensitive to small changes in retinal thickness.⁶

In our study, we observed a linear correlation between the OCT measured macular thickness and both the distance visual acuity and the near visual acuity. That means that for a given level of macular thickness, we can predict visual acuity for it. In our series correlation coefficient was 0.921 for distance visual acuity and 0.899 for near visual acuity.

While in patients with CSME, correlation varied from 0.46 to 0.9 indicating moderate to good correlation. In our study also, we found good relationship between visual acuity and macular thickness. Hence one can be predicted from other. Our study was unique in that we studied correlation between macular thickness and both distance and near visual acuity. Both showed good correlation. Hence both are predictive of macular thickness.

Although the correlation value is high in our study, we did find a range of visual acuities for a given range of macular thickness.

Hence a range of values of near visual acuities are possible for a particular measurement of macular thickness.

Hence a range of values of distance visual acuities are possible for a particular measurement of macular thickness.

So, we conclude that although macular thickness and visual acuities (distance as well as near) are strongly correlated, there can be variations. And a wide range of visual acuities are possible for a given degree of macular edema. Browning et al (2000) observed that a subset of eyes showed paradoxical improvement in visual acuity with increased center point thickening (7%-17%) or paradoxical worsening of visual acuity with reduced center point thickening (180/0-26%). Thus, the predictive value of change in retinal thickening for change in visual acuity in a particular eye is low.

Macular thickness though a strong predictor of visual acuity, other factors might also play a role in determining visual acuity for a particular patient.

CONCLUSION

The present study highlights the correlation between mean macular thickness and presenting visual acuity. This was a prospective study which included 50 eyes of diabetic patients with diabetic retinopathy with clinically significant macular edema (CSME) attending the out-

patient Department of Ophthalmology at MMIMSR, Mullana, Ambala, Haryana.

- Out of total of 50 patients, 22 were females and 28 were males, accounting for 44 % and 56 % of the study group respectively.
- The mean age of patients was 48.82 years, ranging from 25 to 59 year.
- All patients underwent detailed ocular examination, including best corrected visual acuity using Snellen chart and Jaeger/N charts, intraocular pressure measurement using Goldman applanation tonometry, slit lamp biomicroscopy, indirect ophthalmoscopy with +90D/+78D lenses and Optical Coherence Tomography (OCT).
- There were 37 eyes out of total of 50 eyes included in the study, which had non proliferative diabetic retinopathy (NPDR) with CSME; comprising 74% of the total study population. Similarly, 13 eyes out of total of 50 eyes had proliferative diabetic retinopathy PDR with CSME, comprising 26% of the total study population.
- The Best corrected visual acuity (BCVA) for distance ranged from 6/9 to 6/60, with mean of 6/18. 14 patients were having BCVA of 6/9, 14 were having BCVA of 6/12, 9 patients were having BCVA of 6/18, 6 patients were having BCVA of 6/24, 1 patient was having BCVA of 6/36 and 6 patients were having BCVA of 6/60. In Log MAR, BCVA ranged from 0.2 to 1, with mean of 0.438.
- The Best corrected visual acuity (BCVA) for near ranged from N6 to N36, with mean of N12. 11 patients were having BCVA of N6, 11 were having BCVA of N8, 3 patients were having BCVA of N10, 10 patients were having BCVA of N12, 6 patients were having BCVA of N18, 2 patients were having BCVA of N24 and 7 patients were having BCVA of N36. In Log MAR, BCVA ranged from 0.1 to 1, with mean of 0.404.
- OCT measured mean macular thickness ranged from 163 microns to 480 microns with an average of 255.16 microns. The mean macular thickness was divided into four groups. First having mean macular thickness <200, second having thickness between 200-299. Third having thickness between 300-399 and fourth having mean macular thickness \geq 400. 18 patients were having mean macular thickness <200, 19 were having thickness between 200-299, 8 were having thickness between 300-399 and 5 were having thickness 400.
- On applying Kruskal-Wallis Test to analyze whether LogMAR BCVA distance visual acuity differed in four OCT groups, it was found that the test was significant with p value < 0.05.
- Further analysis was done to know intergroup differences, for which Mann -Whitney (non parametric) test was done. As P value was < 0.05, Hence LogMAR distance visual acuity differed statistically significant between different groups.

- Similar tests were applied to analyze the correlation between best corrected visual acuity (BCVA) and OCT measured mean macular thickness, and tests were found to be significant with P value <0.05.
- Our study was unique in that we studied correlation between macular thickness and both distance and near visual acuity. Both showed pretty good correlation. Hence both are predictive of macular thickness.
- In the present study, we observed a linear correlation between the OCT measured macular thickness and both the distance visual acuity and the near visual acuity. That means that for a given level of macular thickness, we can predict visual acuity for it. In our series correlation coefficient was 0.921 for distance visual acuity and 0.899 for near visual acuity. Although the correlation value is high in our study, we did find a range of visual acuities for a given range of macular thickness.
- It was also found in the present study that for every 100 micron change in mean macular thickness, best corrected visual acuity (BCVA) changed 0.3 LogMAR units, for distance as well as for near.
- So, we conclude that although macular thickness and visual acuities (distance as well as near) are strongly correlated, there can be variations. And a wide range of visual acuities are possible for a given degree of macular edema. Macular thickness though a strong predictor of visual acuity; other factors might also play a role in determining visual acuity for a particular patient.

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

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