# A prospective study showing correlation between macular thickness and RNFL thickness measured by SD-OCT in open angle glaucoma in patients attending a tertiary care hospital.

[1]Dr.Shorya Singh,Senior Resident ,Department of Ophthalmology, Government Doon Medical College, Dehradun.

[2]Dr.Ruplai Tyagi, Associate Professor, Department of Ophthalmology, Government Doon Medical College, Dehradun.

[3]Dr. Manisha Gupta, Professor &Head , Department of Ophthalmology, SGRRIMHS, Dehradun.

**Corresponding Author:** Dr. Ruplai Tyagi, Associate Professor, Department of Ophthalmology, Government Doon Medical College, Dehradun.

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## Abstract

**Background:** Glaucoma is among the leading causes of blindness worldwide. It is a group of ocular diseases characterized by optic neuropathy associated with progressive thinning of the neuro-retinal rim and loss of the retinal nerve fibre layer (RNFL) together with a particular pattern of visual field (VF) loss.

**Methods:** A prospective study was performed on patients from ophthalmology OPD of SHRI MAHANT INDIRESH HOSPITAL, Dehradun, Uttarakhand. 120 patients of age 45-65 years were taken up for study underwent thorough history and baseline examination which  includes measurement of best corrected visual acuity,  intraocular pressure,  gonioscopy ,anterior segment  examination  and  posterior  segment examination.

**OCT Analysis:** Superior and inferior macular thickness and RNFL thickness was recorded.

**Data management and statistical analysis:** Statistical analysis was performed by the SPSS program for IOS, version 23.0. continuous variables are presented as mean ± SD, and categorical variables are presented as absolute numbers and percentage. Normally distributed continuous variables were compared using ANOVA by open epi.com. Categorical variables were analyzed using the chi-square test and for correlations Pearson coefficient were used. For all statistical tests, a p value less than 0.05 was taken to indicate a significant difference.

**Results:** In this study the results show that, there is correlation between superior and inferior MT with superior and inferior RNFL thickness.

**Conclusion:** In our study we investigated the utility of using macular thickness for early diagnosis of glaucoma suspects compared to the discriminating ability of RNFL thickness. However, RNFL thickness measurements outperformed macular thickness measurements in our study.

## Introduction

Glaucoma is among the leading causes of blindness worldwide. It is a group of ocular diseases characterized by optic neuropathy associated with

progressive thinning of the neuroretinal rim and loss of the retinal nerve fibre layer (RNFL) together with a particular pattern of visual field loss (VF).[1]

The most recent technology, spectral domain or Fourier domain OCT uses a spectrometer as a detector of OCT signal (2-5) [4-7]. Spectral domain OCT (SD-OCT) has benefits over the time domain OCT (TD-OCT) such as higher axial resolution (3 to 6 μm), up to 200 times faster scanning speed and better reproducibility (6-8) [8-10]. Measurements of optic nerve head, RNFL and macular thicknesses by OCT are using for discrimination between the glaucomatous eyes and normal eyes (9) [11].

In glaucoma patients, in particular, imaging of the optic nerve and of the circumpapillary retinal nerve fibre layer (RNFL), is commonly used. With spectral domain (SD)-OCT, the increased speed of image acquisition, along with improvements in eye tracking, allow for higher resolution images as well as imaging larger areas of the macular region. Algorithms are under development for the measurement of the retinal ganglion cells themselves within the macula, as well as of the retinal ganglion cell complex including the RNFL (10) [12].

The macula is the region of the retina where ganglion cells are in the highest concentration (11) [14].The ganglion cells along with the RNFL contribute 30-35% of the retinal thickness in the macula (12) [15].

For glaucoma patients, an association exists between loss of retinal thickness in the posterior pole and visual function. As glaucomatous damage progresses with the additional loss of retinal ganglion cells, macular thickness changes accordingly (13-14) [16-17].

With the introduction of spectral-domain OCT using eye tracking technology, retinal thickness changes in the macula can be measured with high precision (15) [18].

Hence, the current study was intended to correlate the measured total retinal thickness in the macula by SD-OCT to visual field defect parameters, in primary open angle glaucoma patients and pre perimetric glaucoma. In this study, we investigated the accuracy of the GCA analysis by SD-OCT, compared to RNFL thickness measurements, for differentiating glaucoma suspects from normal controls and those with early and moderate glaucoma.

**Methods**

**Methods:** A prospective study was performed on patients from ophthalmology OPD of SHRI MAHANT INDIRESH HOSPITAL, Dehradun, Uttarakhand. 120 patients of age 45-65 years were taken up for study, who underwent thorough history taking and baseline examination which includes measurement of best corrected visual acuity, intraocular pressure, gonioscopy ,anterior segment examination and posterior segment examination.

**OCT Analysis**

- RNFL thickness was the thickness of RNFL at a calculated 3.45 mm diameter around the centre of the disc. It was measured by disc circle technique in SD-OCT. Both superior and inferior RFNL thickness was recorded.

- After obtaining macular cube scan of 6x6 mm square centred on the fovea, the embedded 3D-OCT program was used to calculate the superior and inferior thickness of the macula.

- The signal strength had to be more than 6 for both optic disc and macular scans.

- **Data management and statistical analysis** Statistical analysis was performed by the SPSS program for IOS, version 23.0. Categorical

variables are presented as absolute numbers and percentage. Normally distributed continuous variables were compared using ANOVA by open epi.com. Categorical variables were analyzed using the chi-square test and for correlations Pearson coefficient were used. For all statistical tests, a p value less than 0.05 was taken to indicate a significant difference.

## Inclusion Criteria

- Established primary open angle glaucoma patients.(Mild to moderate glaucomatous damage according to Hodapp Parrish Anderson Grading).

- Glaucoma suspects with optic disc suspicious for glaucoma were defined as those having all of the following features:

1. BCVA 20/40or more (refractive error±5.0D spherical;±3.0D cylinder).

2. IOP <22 mmHg on at least 2 successive measurements spaced 2 weeks apart at approximately the same time of da .

3. Open angles on gonioscopy.

4. Optic disc suspicion features such as cup-disc ratio >0.6, any diffuse or focal neuroretinal rim thinning, any disc haemorrhage.

5. Normal visual fields defined as that with a mean deviation (MD) and pattern standard deviation (PSD) values within 95% normal confidence limits and a glaucoma hemifield test (GHT) classified as "within normal limits." [13]

- Normal participants were defined as those with no history of ocular or neurologic or systemic disease that might interfere with test results (e.g., diabetic retinopathy, uveitis, significant cataract, etc.), IOP ≤21 mmHg, BCVA of 20/40 or more, open angles on gonioscopy, normal optic discs, and normal visual fields.[13]

- Age group: 45 - 65 years old.

## Exclusion Criteria

- POAG with advanced glaucomatous damage according to Hodapp-Parrish-Anderson criteria.

- Ocular trauma.

- Uveitis.

- High myopes.

- Macular scarring or any other macular pathology due to miscellaneous diseases.

- Macular surgery (retinal surgery/laser).

- Age group more than 65 year old.

## Data management and statistical analysis

Statistical analysis was performed by the SPSS program for IOS, version 23.0. continuous variables are presented as mean ± SD, and categorical variables are presented as absolute numbers and percentage. Normally distributed continuous variables were compared using ANOVA by open epi.com. Categorical variables were analyzed using the chi-square test and for correlations Pearson coefficient were used. For all statistical tests, a p value less than 0.05 was taken to indicate a significant difference.

## Results

A total 120 eyes were studied and divided into 4 groups; Suspect, Early glaucoma (EG), Moderate glaucoma (MG) and Control equally having 30 eyes in each group.

**Age Distribution**

Table 1: Distribution of patients on basis of their age and respective groups

(N=120 eyes)

| Age group | Suspect | EG | MG | Control |
|---|---|---|---|---|
| 45-55 years | 28(23.33%) | 18(15%) | 16(13.33%) | 18(15%) |
| 56-65 years | 2(1.67%) | 12(10%) | 14(11.67%) | 12(10%) |

We studied patients of age between 45 years to 65 years

of age. Most of the patients were in 45-55 years of age

in all groups,

**Gender Distribution**

Table 2: Distribution of patients on basis of their gender and respective groups (N=120 eyes)

| Gender | Suspect | EG | MG | Control |
|---|---|---|---|---|
| Male | 10(8.33%) | 16(13.33%) | 18(15%) | 16(13.33%) |
| Female | 20(16.67%) | 14(11.37%) | 12(10%) | 14(11.67%) |

There were 60 male and 60 female eyes. In the suspect groups of glaucoma, 10 were male & 20 were female eyes, similarly, in EG group 16 were male & 14 female eyes, in MG 18 were male & 12 females eyes and in control group there were 16 males and 14 female eyes.

**Clinical Characteristics**

Table 3: Distribution of patients on basis of their clinical presentation (N=120 eyes)

| Clinical Characteristic | Suspect (n=30) | EG (n=30) | MG (n=30) | Control (n=30) |
|---|---|---|---|---|
| IOP | 19.73±1.27 | 21.13±1.45 | 23.73±1.83 | 11.86±1.18 |
| VCD Ratio | 0.83±0.65 | 0.52±0.82 | 0.61±0.19 | 0.32±0.06 |
| MD | -2.59±1.49 | -4.89±0.88 | -7.20±0.39 | -2.13±0.63 |
| Macular Thickness | | | | |
| Superior | 289±2.61 | 274.06±2.34 | 268.46±3.67 | 298.93±3.51 |
| Inferior | 287±4.85 | 272±3.96 | 267.93±4.73 | 297.03±2.71 |
| RNFL Thickness | | | | |
| Superior | 98.3±2.35 | 79.26±2.25 | 69.13±3.59 | 101.85±1.23 |
| Inferior | 96.2±1.09 | 77.86±3.18 | 67. 73±3.48 | 101.31±1.12 |

The clinical presentation of all eyes (N=120 eyes) were

reported in following table and found controls were

more comparable in all variables with all other groups.

Macular and RNFL thickness was also reported and

found controls were better than case groups.

**Macular Thickness Analysis In Glaucoma Suspect**

Table 4: Distribution of glaucoma suspect patients on basis of macular thickness analysis (N=30 eyes)

| MT | Normal | Mild | Moderate | Severe |
|---|---|---|---|---|
| Superior (n=30) | 294.2±3.14 (n=11) | 288±2.72 (n=9) | 285.87±2.61 (n=8) | 283.56±3.12 (n=2) |
| Inferior (n=30) | 292.75±2.52 (n=6) | 286.16±4.07 (n=6) | 283.38±2.81 (n=14) | 281.5±3.43 (n=4) |

Macular thickness (MT) analysis has been reported for eyes of glaucoma suspect (preperimetric glaucoma) group and found out of 30 superior MT findings 11 eyes with normal MT with mean 294.2±3.14, 9 eyes with mild macular thinning with mean 288±2.72, 8 eyes with moderate macular thinning with mean 285.87±2.61 and only 2 eyes had severe macular thinning with mean 283.56±3.12. Similarly, in Inferior MT findings, 14 eyes with moderate macular thinning with mean 283.38±2.81, 6 eyes with normal MT with mean 292.75±2.52, 6 eye with mild macular thinning with 286.16 ±4.07and only 4 eyes with severe macular thinning with mean 281.5±3.43.

**Macular Thickness Analysis in Early Glaucoma (EG) Group**

Table 5: Distribution of early glaucoma group eyes on basis of macular thickness analysis (N=30 eyes)

| MT | Normal | Mild | Moderate | Severe |
|---|---|---|---|---|
| Superior (n=30) | 282.25±6.13 (n=4) | 278.2±6.0 (n=6) | 270±5.52 (n=14) | 262.06±3.74 (n=6) |
| Inferior (n=30) | 281±3.41 (n=2) | 274.75±1.87 (n=4) | 269.69±5.34 (n=18) | 261.2±2.73 (n=6) |

Macular thickness analysis has been reported for eyes of early glaucoma groups and found in 30 superior MT findings 4 eyes with normal MT with mean 282.25±6.13, 6 eyes with mild macular thinning with mean 278.2±6, 14 eyes with moderate macular thinning with mean 270±5.52 and 6 eyes with severe macular thinning with mean 262.06±3.74. Similarly, in Inferior MT findings of early glaucoma, 18 eyes with moderate macular thinning with mean 269.69±5.34, 2 eye with normal MT with mean 282.25±6.13, 4 eye with mild macular thinning with 274.75±1.87 and only 6 eyes with severe macular thinning with mean 261.2±2.73.

**Macular Thickness Analysis In Moderate Glaucoma (Mg) Group**

Table 6: Distribution of moderate glaucoma group eyes on basis of macular thickness analysis (N=30 eyes)

| MT | Normal | Mild | Moderate | Severe |
|---|---|---|---|---|
| Superior (n=30) | Nil (n=0) | 271.5±5.13 (n=8) | 267.41±2.10 (n=13) | 260.88±3.08 (n=9) |
| Inferior (n=30) | Nil (n=0) | 269.8±4.76 (n=5) | 263.66±3.16 (n=15) | 258.04±2.13 (n=10) |

Macular thickness analysis has been reported for eyes of moderate glaucoma groups and found in 30 superior MT findings nil eyes had normal MT, 8 eyes with mild macular thinning with mean 271.5±5.13, 13 eyes had moderate macular thinning with mean 267.41±2.10 and 9 eyes had severe macular thinning with mean 260.88±3.08. Similarly, in Inferior MT findings of early glaucoma, 15 eyes with moderate macular thinning with mean 263.66±3.16, 5 eye had mild macular thinning with mean 269.8±4.76,10 eyes had severe macular thinning with mean 258.04±2.13 and nil eyes were found in normal MT.

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Table 7: Comparative analysis of Superior MT findings of Glaucoma suspect, EG & MG (N=30 eyes for each group)

| Superior MT | Normal | Mild | Moderate | Severe | P-value |
|---|---|---|---|---|---|
| Suspect | 294.2±3.14 (n=11) | 288±2.72 (n=9) | 285.87±2.61 (n=8) | 283.56±3.12 (n=2) | <0.0001 |
| EG | 282.25±6.13 (n=4) | 278±2.60 (n=6) | 270±5.52 (n=14) | 262.6±3.74 (n=6) | <0.0001 |
| MG | -(n=0) | 271.5±5.13 (n=8) | 267.41±2.10 (n=13) | 260.88±3.08 (n=9) | <0.0001 |

(Chi-square =255, degree of freedom =6 )

Comparison between superior MT findings of glaucoma suspect, EG & MG groups was analyzed and found there is statistically highly significant correlation between them with p value <0.001.

Table 7: Comparative analysis Of Inferior MT findings of Glaucoma suspect, EG & MG (N=30 eyes for each group)

| Inferior MT | Normal | Mild | Moderate | Severe | P-value |
|---|---|---|---|---|---|
| Suspect | 292.75±2.52 (n=6) | 286.16±4.07 (n=6) | 283.3±2.81 (n=14) | 281.51±3.43 (n=4) | <0.001 |
| EG | 281±3.41 (n=2) | 274.7±1.89 (n=4) | 269.69±5.34 (n=18) | 261.2±2.73 (n=6) | <0.001 |
| MG | Nil (n=0) | 269.8±4.76 (n=5) | 263.66±3.16 (n=15) | 258.04±2.13 (n=10) | <0.001 |

( Chi-square =255, degree of freedom =6 )

Comparison between inferior MT findings of glaucoma suspect, EG & MG groups was analyzed and found there is statistically highly significant correlation between them with p value <0.001.

Retinal Nerve Fiber Layer Thickness Analysis In Glaucoma Suspect (RNFLT)

Table 8: Distribution of glaucoma suspect group eyes on basis of RNFL thickness analysis   (N=30 eyes)

| RNFLT | Normal | Mild | Moderate | Severe |
|---|---|---|---|---|
| Superior(n=30) | 104.85±3.79 (n=14) | 94±2.56 (n=9) | 88.5±2.51 (n=4) | 80.33±8.69 (n=3) |
| Inferior (n=30) | 104.09±3.38 (n=11) | 93.25±2.37 (n=10) | 86.83±3.37 (n=6) | 72.68 ± 6.13 (n=3) |

RNFL thickness analysis has been reported for eyes of glaucoma suspect groups and found in 30 superior RNFLT findings 14 eyes with normal RNFLT with mean 104.85±3.79, 9 eyes had mild RNFL thinning with mean 94±2.56,4 eyes with moderate RNFL thinning with mean 88.5±2.51 and only 3 eyes  had severe RNFL thinning with mean 80.33±8.69.

Similarly, in Inferior RNFLT findings of glaucoma suspect, 11 eye were found to be with normal RNFLT with mean 104.09±3.38, 10 eyes had mild RNFL thinning with mean 93.25±2.37, 6 eye with moderate RNFL thinning with mean 86.83±3.37 and only 3 eyes with severe RNFL thinning with mean 72.68±6.13.

Table 9: Distribution of early glaucoma group eyes on basis of RNFL thickness analysis   (N=30 eyes)

| RNFLT | Normal | Mild | Moderate | Severe |
|---|---|---|---|---|
| Superior  (n=30) | 95.5±9.28  (n=8) | 82.8 ±2.41 (n=11) | 76.33±1.63 (n=8) | 61.33±6.11 (n=3) |
| Inferior  (n=30) | 93.5±8.41  (n=4) | 81.25±4.31 (n=12) | 73.63 ± 2.64 (n=9) | 57.25 ± 3.18 (n=5) |

RFNL thickness analysis has been reported for eyes of early glaucoma groups and found in 30 superior RNFLT findings 8 eyes with normal RNFLT with mean 95.5±9.28, 11eyes had mild RNFL thinning with mean 82.8±2.41, 8 eyes with moderate RNFL thinning with mean 76.33±1.63 and only 3 eyes  had severe RNFL thinning  with mean 61.33±6.11. Similarly, in Inferior RNFLT findings of early glaucoma, 4 eyes were found with normal RNFLT with mean 93.5±9.28, 12 eyes had mild RNFL thinning with mean 81.25±4.31, 9 eyes with moderate RNFL thinning   with mean73.63±2.64 and only 5 eyes had severe RNFL thinning with mean 57.25±3.18.

Table 10: Distribution of moderate glaucoma group eyes on basis of RNFL thickness analysis (N=30 eyes)

| RNFLT | Normal | Mild | Moderate | Severe |
|---|---|---|---|---|
| Superior  (n=30) | Nil  (n=0) | 77.33±1.21  (n=6) | 65.42 ± 3.81 (n=16) | 57.5±3.57  (n=6) |
| Inferior  (n=30) | Nil  (n=0) | 72.75±3.57  (n=8) | 62.12±6.12 (n=15) | 53±4.17  (n=7) |

RNFL thickness analysis has been reported for eyes of moderate glaucoma groups and found in 30 superior RNFLT findings nil eyes had normal RNFLT, 6 eyes with mild RNFL thinning with mean 77.33±1.21, 16 eyes had moderate RNFL thinning with mean 65.42±3.81 and only 6 eyes  had severe RNFL thinning with mean 57.5±3.57. Similarly, in Inferior RNFLT findings of moderate glaucoma, nil eyes were found with normal RNFLT, 8 eyes with mild RNFL thinning with mean 72.75±3.57, 15 eyes had moderate RNFL thinning with mean 62.12±6.12 and 7 eyes with severe RNFL thinning with mean 53±4.17.

Table 11: Comparative analysis of Superior RNFLT findings of Glaucoma suspect, EG & MG (N=30 eyes for each group)

| Superior FNLT | Normal | Mild | Moderate | Severe | P-value |
|---|---|---|---|---|---|
| Suspect | 104.85±3.79 (n=14) | 94±2.56  (n=9) | 88.5±2.51  (n=4) | 80.33±8.69  (n=3) | <0.0001 |
| EG | 95.5±9.28  (n=8) | 82.8±2.41  (n=11) | 76.33±1.63  (n=8) | 61.33±6.11 (n=3) | <0.0001 |
| MG | Nil  (n=0) | 77.33±1.21 (n=8) | 65.42±3.81 (n=16) | 57.5±3.57  (n=6) | <0.0001 |

(Chi-square =76.82, degree of freedom = 6 )

Comparison between superior RFNLT findings of glaucoma suspect, EG & MG groups was analyzed and found there is statistically highly significant correlation between them with p value <0.001.

Table 12: Comparative analysis of Inferior RNFLT findings of Glaucoma suspect, EG & MG (N=30 eyes for each group)

| Inferior RNFLT | Normal | Mild | Moderate | Severe | P-value |
|---|---|---|---|---|---|
| Suspect | 104.09±3.3 (n=11) | 93.25±2.37 (n=10) | 86.83±3.3 (n=6) | 72.68±6.13 (n=3) | <0.001 |
| EG | 935±8.41 (n=4) | 81.25±4.31 (n=12) | 73.63±2.64 (n=9) | 57.25±3.18 (n=5) | <0.001 |
| MG | Nil (n=0) | 72.75±3.57 (n=8) | 62.12±6.12 (n=15) | 53±4.17 (7) | <0.001 |

(Chi-square =255, degree of freedom =6 )

Comparison between inferior RFNLT findings of glaucoma suspect, EG & MG groups was analyzed and found there is statistically highly significant correlation between them with p value <0.001.

Table 13: Correlation between Macular Thickness (superior & inferior) and RNFL Thickness (superior & inferior)

| Correlations | | MTSUP | MTINF | RNFLSUP | RNFLINF |
|---|---|---|---|---|---|
| MTSUP | Pearson Correlation | 1 | .943** | .791** | .819** |
| | Sig. (2-tailed) | | .000 | .000 | .000 |
| | N | 60 | 60 | 60 | 60 |
| MTINF | Pearson Correlation | .943** | 1 | .810** | .855** |
| | Sig. (2-tailed) | .000 | | .000 | .000 |
| | N | 60 | 60 | 60 | 60 |
| RNFLSUP | Pearson Correlation | .791** | .810** | 1 | .893** |
| | Sig. (2-tailed) | .000 | .000 | | .000 |
| | N | 60 | 60 | 60 | 60 |
| RNFLINF | Pearson Correlation | .819** | .855** | .893** | 1 |
| | Sig. (2-tailed) | .000 | .000 | .000 | |
| | N | 60 | 60 | 60 | 60 |

**. Correlation is significant at the 0.01 level (2-tailed).

Table no 13 deals with the correlation between MT SUP with MT INF, RNFL SUP and RNFL INF. MT SUP was strongly correlated to MT INF (Pearson correlation of 0.943) followed by RNFL INF (0.819) and RNFL SUP (0.791). Similarly MT INFL strongly correlates with MT SUP (Pearson correlation of 0.943) followed by RNFL INF (0.8551) and RNFL SUP (0.810). RNFL SUP strongly correlate with RNFL INF (Pearson correlation of 0.893) followed by MT INF (0.810) and MT SUP (0.791). RNFL INF strongly correlates with RNFL SUP (Pearson correlation of 0.893) followed by MT INF (0.855) and MT SUP (0.819).
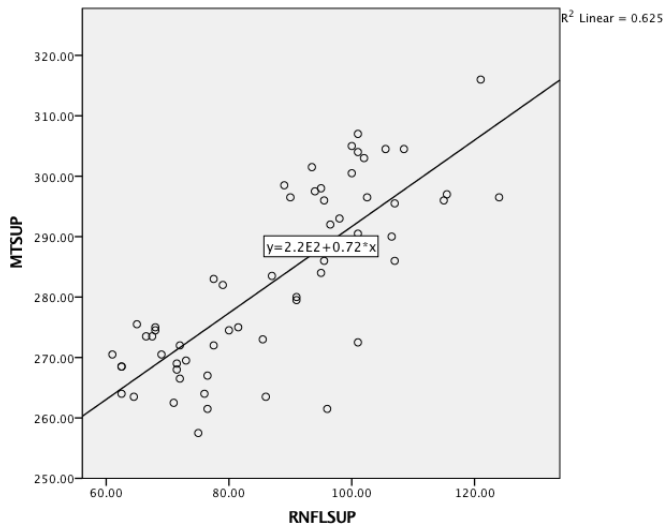
Figure 1: MT superior and RNFL superior

In figure 1, explains the difference in the macular thickness and retinal nerve fiber layer thickness for superior half has correlated significantly with r=0.625, $p < 0.001$, 1 unit change in RNFL SUP produces 0.625 unit change in MT SUP.
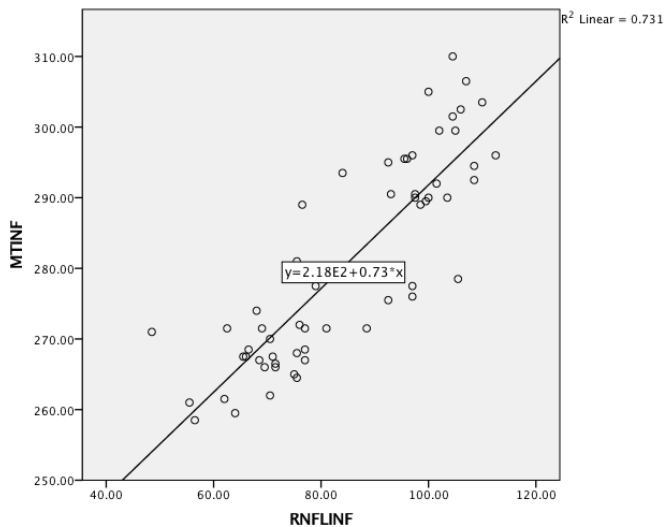


Figure 2: Scatter plot graph between inferior MT and RNFLT

In figure 2, explains the difference in the macular thickness and retinal nerve fiber layer thickness for inferior half has correlated significantly with r=0.731, $p < 0.001$, 1 unit change in RNFL INF produces 0.731 unit change in MT INF.

## Discussion

**Age Distribution:** In present study the patients recruited were in the age group ranging from 45 years to 65 years which is further divided in to two sub groups of age as 45-55 years and 56-65 years and in 45-55 years group the majority of patients were of suspect glaucoma (23.33%) followed by controls and EG with 18% each while in 56-65 years groups the majority of patients were of moderate glaucoma (11.67) followed by EG and controls with 10.0% each. **Lui CH et al** (17) [57] reported the mean age of the studied patients as 54.73±12.39 years in their study. **Kaushik S et al** (16) [13] depicts the mean age as 59.06±12.62 in their study.

**Gender Distribution:** In our study out of the total 120 studied patients male and females were equally distributed with 60 male patients and 60 female patients. **Lee HJ et al** (18) [58]reported in their study that out of total 88 patients 42 were males and 46 were females.

**Clinical Characteristics :** In present study the mean intraocular pressure (IOP) was observed to be 19.73±1.27 mmHg for glaucoma suspect, 21.13±1.45 mmHg for early glaucoma, 23.73±1.83 mmHg for moderate glaucoma,  and 11.86±1.18 mmHg for the controls. Mean deviation (MD) was -2.59±1.49 for glaucoma suspect, -4.89±0.88 for early glaucoma, -7.20±0.39 for moderate glaucoma and -2.13±0.63 for controls. **KaushikS et al** who reported IOP for glaucoma as 25.04±3.77 mmHg and that of controls as 14.86±2.82 mmHg, MD was -5.17±2.6 while PSD was 3.83±2.5.

In present study the superior macular thickness was observed to be 268.46±3.67 for MG, 274.06±2.34 for EG,289±2.61 for glaucoma suspect and 298.93±3.51 for controls. Inferior macular thickness was

267.93±4.73 for MG, 272±2.34 for EG, 287±4.85 for glaucoma suspect and 297.03±2.71 for controls. Superior RNFL thickness is 69.13±3.59 for MG, 79.26±2.25 for EG, 98.3±2.35 for glaucoma suspect and 101.85±1.23 for controls. Inferior RNFL thickness as 67. 73±3.48 for MG, 77.86±3.18 for EG, 96.2±1.09 for glaucoma suspect and 101.31±1.12 for controls. **Lee HJ et al** who reported superior and inferior RNFL as 113.7±15.0 and 111.7±17.7 respectively.

**Superior MT comparison between Glaucoma suspect, EG & MG:** In present study severe thinning of superior macular thickness noticed in 2 cases of glaucoma suspect (283.56±3.12) and 28 cases had mild to moderate macular thinning (288±2.72 - 285.56±3.12) with p <0.0001. In cases of EG, 6 cases had severe thinning(262.6±3.74) while 20 cases had mild to moderate macular thinning (278±2.6 - 270±5.52) with p value <0.0001. In cases of MG, 9 cases had severe thinning(260.88±3.08) while 21 cases had moderate to mild macular thinning (271.5±5.13 - 267±2.10) with p value <0.0001. This shows significant macular thinning in MG as compared to glaucoma suspect and EG. Also there was a statistically significant association between superior and inferior MT using Pearson correlation (943) with Sig.(2-tailed) was .0001. **Hung KC et al (19) [63]** reported the significant association between superior and inferior macular thickness of glaucoma suspect, EG and MG (p<0.05). **Xu X et al** (20) [45]in their study also reported the significant association of superior macular thickness with glaucoma suspect with early to moderate glaucoma (p<0.05). Ganglion cell loss in glaucoma may result in a decrease in macular cellularity and thickness (p<0.05) (21) [44].

**Inferior MT Comparison between Glaucoma Suspect, EG & MG:** In our study severe thinning of inferior macular thickness noticed in 4 cases of glaucoma suspect (281.51±3.43) and 26 cases had mild to moderate macular thinning (286.3±2.81 - 283.3±2.18) with p <0.0001. In cases of EG, 6 cases had severe macular thinning(261.2±2.73) while 22 cases had mild to moderate macular thinning (274±1.89 - 269.69±5.34) with p value <0.0001. In cases of MG, 10 cases had severe thinning(258.04±2.13) while 20 cases had mild to moderate macular thinning (269.8±4.76 - 263.66±3.16) with p value <0.0001. This shows significant inferior macular thinning in MG as compared to glaucoma suspect and EG. Also there was a statistically significant association between inferior and superior MT using Pearson correlation (943) with Sig.(2-tailed) was .0001. **Hung KC et al (19)** [63] reported the significant association between superior macular thinning of glaucoma suspect, EG and MG (p<0.05). **Xu X et al (20)** [45] in their study also reported the significant association of inferior macular thickness thinning of glaucoma suspect with early to moderate glaucoma (p<0.05).

**Superior RNFLT Comparison between Glaucoma Suspect, EG&MG:** In present study severe thinning of superior RNFL thickness noticed in 3 cases of glaucoma suspect (80.33±8.69) and 13 cases had mild to moderate RNFL thinning (94±2.56 - 88.5±2.51) with p <0.0001. In cases of EG, 3 cases had severe thinning (61.33±6.11) while 19 cases had mild to moderate RNFL thinning (82.8±2.41 - 76.33±1.63) with p value <0.0001. In cases of MG, 6 cases had severe thinning (57.5±3.57) while 24 cases had moderate to mild RNFL thinning (65.42±3.81 - 77±1.21) with p value <0.0001. Also there was a statistically significant association between superior and inferior RNFLT using Pearson correlation (893) with Sig.(2-tailed) was .000 .**Sengupta S** (21) [44] reported in his study that RNFLT for glaucoma

suspects as 112±13.4, early glaucoma 94±8.68 while that of moderate to severe glaucoma RNFLT was 74±7.82 and the association was statistically significant (p<0.05). Another study by **El-Naby AE et al (22)** [65] superior RFNLT quadrant was found as 124.55±6.95 for controls, 109.33±8.72 for early, 91.47±8.75 and for severe it was 76.5±6.61 (p<0.05).

**Inferior RFNLT comparison Between Glaucoma Suspect, EG&MG:** In present study severe thinning of inferior RNFL thickness noticed in 3 cases of glaucoma suspect (72.68±6.13) and 16 cases had mild to moderate RNFL thinning (93.25±2.37 - 86.83±3.3) with p <0.0001. In cases of EG, 5 cases had severe thinning (57.25±3.18) while 21 cases had mild to moderate RNFL thinning (81.25±4.31 - 73.63±2.64) with p value <0.0001. In cases of MG, 7 cases had severe thinning (53±4.17) while 23 cases had moderate to mild RNFL thinning (62.12±6.12 - 72.75±3.57) with p value <0.0001. Also there was a statistically significant association between inferior and superior RNFLT using Pearson correlation (893) with Sig.(2-tailed) was .000. **El-Naby AE et al (22)** [65] reported inferior RFNLT quadrant as 124.55±6.95 for controls, 109.33±8.72 for early, 91.47±8.75 and for severe it was 76.5±6.61 (p<0.05). **XU X et al (20)** [45] and **Sengupta S (21)** [44]also found the similar findings in their respective studies (p<0.05).

Macular thickness for moderate glaucoma (MG) was found as highly statistically significant (p<0.0003) .**Mathers et al** (23) [40] stated that eyes with a total macular thickness of <270 mm were significantly more likely to be associated with visual field loss, by MD. However, eyes with a total macular thickness of >300 mm were less likely to be associated with visual field losses.Also, **Motlagh BF** (24) [56] showed significant structure–function correlation between macular

thickness measured by SD-OCT and visual field variables.

**Association between macular thickness and RNFL thickness:** In our study there were a significant association between superior macular thickness and superior retinal nerve fiber layer thickness with r=0.625, p<0.001and inferior macular thickness and inferior retinal nerve fiber layer thickness with r=0.731, p<0.001. **Motlagh BF** (24) [56] showed significant association between macular thickness and retinal nerve fiber layer thickness in both superior as well as inferior quadrant which is in accordance with our study.

Glaucoma being caused due to death of RGCs, and RGCs being concentrated at the macula have led investigators to explore the possibility of using macular thickness as a useful discriminator for glaucoma (25) [69].

In our study we investigated the utility of using macular thickness for early diagnosis of glaucoma suspects compared to the discriminating ability of RNFL thickness. However, RNFL thickness measurements out performed macular thickness measurements in our study.

One reason for this could be in the inherent pathophysiology of glaucomatous RGC loss. The spatial distribution of different ganglion cells in the retina (26-27) [72-73] is such that predominantly large cells which map to the magnocellular region of the lateral geniculate body (LGB) are designated "M" cells and are found mainly outside the central foveal region. A far greater number of smaller cells which map to the parvocellular region of the LGB are designated "P" cells, represent the majority of RGCs, and are distributed mainly in the parafoveal area.

Although RGCs are maximally concentrated at the macula, they are predominantly the smaller "P" cells,

and if the larger "M" cells are lost in early glaucoma, it can be understood why GCA by OCT may not detect very early glaucoma.This suggests that RNFL thickness measurements may, in fact, be a better indicator of very early RGC loss since it takes into account average thickness of all axons converging on the optic nerve and is more likely to include axons subserving the M cells also.

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