Original Article

Measurement of Optic Disc Diameter and CD Ratio Using OCT Imaging and Fundus Stereo-biomicroscopy to Find an Agreement between the Two

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Purpose: To compare the clinician disc assessment findings with OCT estimation and to assess the agreement.

Study Design: Observational study.

Place and Duration of Study: North Devon District Hospital, UK from January 2017 and April 2017.

Material and Methods: This is an observational study of 100 eyes of 50 consecutive patients. All patients and eyes were examined by one single clinician. Vertical disc height was measured by the clinician using the slit lamp narrow beam of light. CD ratio was estimated by comparing the cupped area of the optic disc with the neuro-retinal rim of the optic disc considering the overall optic disc size. OCT was used for automated disc examination and to assess disc parameters. The agreement between the two methods was analyzed statistically by intraclass correlation coefficient (ICC).

Results: There was a good correlation seen between the two methods while assessing vertical disc diameters and CD ratio (r = 0.65, 0.66 respectively). There was a substantial strength of agreement (according to ICC agreement criteria) in both clinician and OCT estimated values in the measurement of vertical disc diameter and CD ratio. The ICC values were 0.77 (CI = 0.66, 0.84) and 0.70 (CI = 0.28, 0.85) respectively.

Conclusion: In this study, the agreement is much greater for both important disc parameters between OCT and clinician methods and clearly it is substantial but still not perfect. OCT and clinician measured observations for optic disc measurements are still not interchangeable in clinical practice.

Keywords: CD ratio; OCT; Vertical disc diameter.

Optic disc examination is an important part of glaucoma assessment for its screening and monitoring in routine ophthalmology clinical practice. It has played a pivotal role historically in the diagnosis and management of glaucoma. Generally, the optic disc size is measured on fundoscopy by the clinician along with the estimation of cup to disc ratio (CD ratio) and optic disc rim thickness. Usually the vertical optic disc height and CD ratio is measured on the slit lamp however along with it, Heidelberg retinal tomography (HRT) and more recently Optical coherence tomography are being utilized more routinely for such measurements of the optic disc for diagnosis as well as follow up of glaucoma patients routinely. Previously, studies have been carried out to compare the measurements of optic disc performed by

the clinicians fundus examination with that of HRT[1,2]. Some researchers have used digital stereo optic disc camera (Discam) and HRT in measuring the CD ratio[3]. However, to our best knowledge there has been no comparative study in the literature, which assessed both these disc parameters (CD ratio & vertical disc diameter) in a single study comparing the agreement between the OCT disc measurements with the clinicians' slit lamp bio-microscopy disc measurements. Hence, we have carried out this study on these two important optic disc parameters to compare the clinicians disc assessment findings with OCT estimation and to assess the agreement or otherwise between the two.

STUDY DESIGN

Observational study of the patients examined for Glaucoma assessment in the eye clinic in a District Regional Hospital.

MATERIAL AND METHODS

This is an observational study of 100 eyes of 50 consecutive patients attending the glaucoma assessment clinic at North Devon District Hospital between January 2017 and April 2017. All patients in the clinic were referred with a query of glaucoma by the community opticians but not already diagnosed with glaucoma. The research was approved by North Devon District Hospital NHS trusts ethics committee. The protocol and methods undertaken in the study for patients were followed in accordance with the tenets of the declaration of Helsinki. Patients included in the study were adults with Snellen chart visual acuity of 6/24 or better and those who had good quality images of their optic discs with OCT scan. Patients with previous ocular trauma and with dense media opacities like corneal scarring, dense brown or white cataracts or vitreous haze due to any other cause limiting the fundal view for slit lamp examination and OCT imaging were excluded from the study. High myopic (-6D or greater) individuals were also excluded from the study.

Patients were examined in the eye clinic thoroughly with focus on the fundal optic disc examination. All patients and eyes were examined by one single clinician. Haag Streit Slit Lamp (Haag Streit bm 900, Switzerland) was used for examination and all patients were examined with dilated pupils using mydriatic drops for pupil dilation. +60 Diopters double aspherical fundus (Volk opticals) lens was used to assess the optic disc. Correction factor was not required for slit lamp biomicroscopy disc height measurements as +60 dioptres lens does not require a correction factor. Vertical disc height was measured by the clinician, using the slit lamp narrow beam of light. The vertical length of the slit lamp beam of light coinciding with the optic disc margin vertically was recorded from the millimeter scale of the slit lamp. CD ratio was estimated by comparing the cupped area of the optic disc with the neuro-retinal rim of the optic disc considering the overall optic disc size. Topcon 3D-OCT 2000 model was used for automated disc examination and to assess disc parameters. OCT is beginning to be widely used for assessing optic disc parameters in glaucoma clinical practice. OCT works on the principle of using low coherence interferometry and produce in-vivo cross sectional scans of retinal structures[4,5,6]. OCT has been used by researchers to assess the retinal nerve fiber layer and to assess the topography of the optic disc[5,6]. Patients were registered on the Topcon OCT individually and each patient had individual OCT assessment of their optic disc. Based on the edges of the RPE of each B-scan, the OCT software automatically estimates the optic disc margin. Vertical as well as horizontal optic disc diameters and CD ratios were obtained from OCT measurement options for each patient. OCT uses the cross points of the reference plane and the internal limiting membrane of the retina for estimating CD ratios.

The data of 100 eyes obtained from Slit Lamp Biomicroscopy and from the OCT scanning was analyzed with SPSS version 10 and Microsoft office Excel version 2010.

The agreement between the two methods for measuring the vertical disc diameter and CD ratio parameters was analyzed statistically by intraclass correlation coefficient (ICC) and Pearson correlation coefficient (r) was used for correlation. Fleiss and Cohen have described the ICC as a measure of reliability for assessing the level of agreement for quantitative data[6]. Landis and Koch have interpreted the ICC in table-1 by describing the relevant strength of agreement for categorical data[7]. We also used a statistical analysis using graphical methods for agreement which is described by Bland and Altman[8]. Paired *t* tests were carried out to find a statistically significant difference between the two methods of measurements and a p-value < 0.05 was considered significant.

RESULTS

The mean vertical disc diameter of 100 patients recorded by the clinician on slit lamp fundoscopy was 1.76 mm, while OCT scanning estimated it to be 1.80 mm and the mean clinician CD ratio was 0.56 while OCT estimated it to be 0.68 as mentioned in table 2. The mean difference of values by the two methods was 0.04 (95% CI = 0.001, 0.08) for vertical disc diameter where OCT measured the disc diameter to be slightly larger than clinician ($p < 0.05$, paired t test) and 0.11 (95% CI = 0.08, 0.14) for CD ratio where OCT measured the CD ratio to be significantly larger than the clinician ($p < 0.0001$, paired t test). Bland Altman plots of differences of the optic disc diameter values and CD ratios against the average of these two parameters in OCT and clinician measurements are shown in figures 1 and 2 respectively. There was a good correlation seen between the two methods while assessing vertical disc diameters and CD ratio (r = 0.65, 0.66 respectively) as shown in figure 3 and 4 respectively. There was a substantial strength of agreement (according to ICC agreement criteria) in both clinician and OCT estimated values in the measurement of vertical disc diameter and CD ratio. The ICC values were 0.77 (CI = 0.66, 0.84) and 0.70 (CI = 0.28, 0.85) respectively.

Table 1: Agreement measures for categorical Data.

Intraclass Correlation Coefficient (ICC)	Strength of Agreement
< 0.00	Poor
0.00-0.20	Slight
0.21-0.40	Fair
0.41-0.60	Moderate
0.61-0.8	Substantial
0.81-1.00	Almost perfect

Table 2: Mean and difference (with 95% CI) of OCT and slit lamp clinician values of vertical disc diameter and CD ratio.

Mean Clinical Vertical Disc Diameter in mm (95% CI)	Mean OCT Vertical Disc Diameter in mm (95% CI)	Difference-Clinician & OCT Vertical Disc Diameter in mm (95% CI)	Mean Clinician CD Ratio (95% CI)	Mean OCT CD Ratio (95% CI)	Difference-Clinical & OCT CD Ratio (95% CI)
1.76 (1.72, 1.80)	1.80 (1.75, 1.85)	0.04(0.001, 0.08)	0.56 (0.53,0.59)	0.68 (0.64,0.72)	0.11 (0.08,0.14)

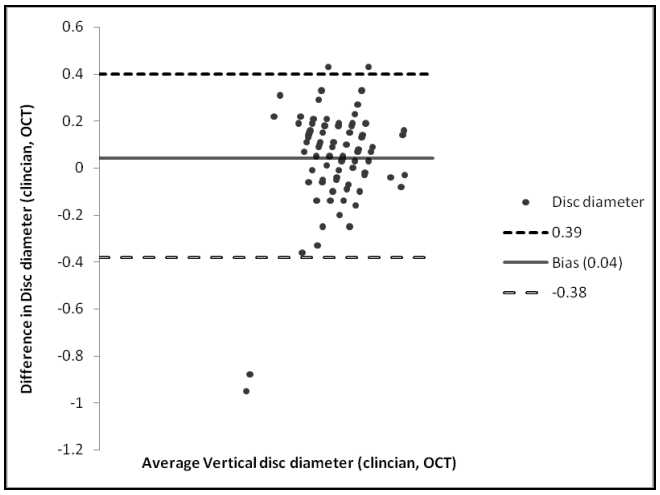

Fig. 1: Bland and Altman plot for agreement between clinician stereo-biomicroscopy and OCT vertical disc diameters.

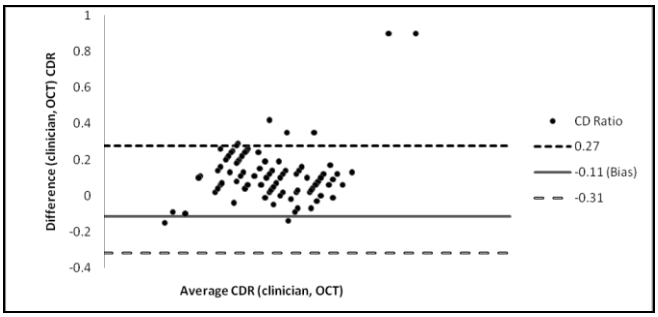

Fig. 2: Bland and Altman plot for agreement between clinician stereo-biomicroscopy and OCT cup disc ratios.

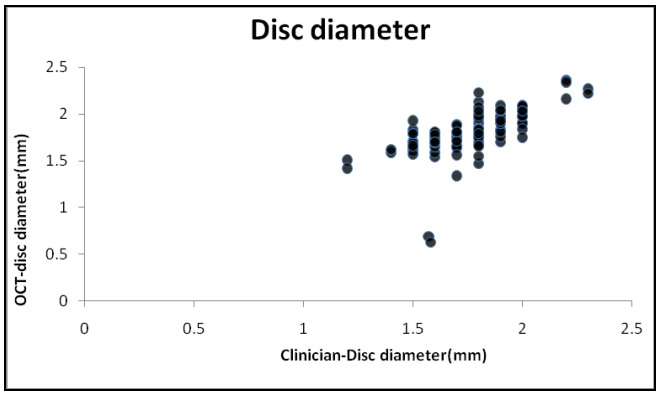

Fig. 3: Graph showing correlation between clinician and OCT vertical disc diameter.

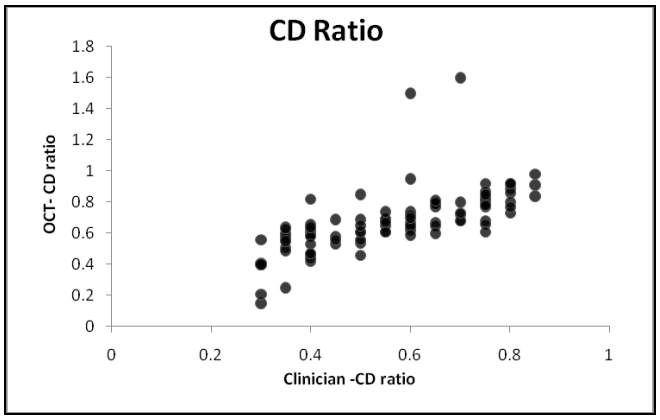

Fig. 4: Graph showing correlation between clinician and OCT cup disc ratios.

DISCUSSION

Optic nerve assessment in general and estimation of optic disc diameter and CD ratio in particular are very important parts of glaucoma assessment and management. Researchers have previously shown that glaucomatous visual field loss is preceded by optic disc damage[9,10]. Reproducibility of Retinal nerve fibre layer analysis and optic disc parameter measurements using OCT modality has been established previously by researchers[11,12]. There has been studies, which have utilized different methods to assess the optic disc parameters and to compare the different methods of assessment. Most of these studies have compared the CD ratio using HRT as one of the methods of assessment to find an agreement between HRT values with other methods, mainly slit lamp biomicrocopy[2,3,13,14]. However, far less number of studies have assessed the optic disc diameter for this purpose. Optic disc diameter is the most important disc parameter and has a pivotal role in determining other disc parameters, e.g., the size of both optic disc rim and CD ratio parameters are very much linked and dependent on it[15,16,17]. Watkins et al. assessed vertical CD ratio to study the agreement between direct Ophthalmoscopic, fundus bio-microscopic and HRT estimated values[14]. They found a moderate agreement between clinician values and HRT in their work, however in our study, we found a better, substantial agreement for CD ratio estimation between the fundus bio-microscopy and OCT estimated values.

Some researchers have assessed the vertical disc diameters by fundoscopy using 60, 78 and 90 D lenses with that of HRT for finding a correlation between them[18]. In their study the correlation was substantially good between the two methods when using 60 D lens however it reduced with 90 D lens (r = 0.80 with 60D lens and r = 0.59 with 90D lens). In our study, OCT and 60 D lens values for vertical disc diameter correlated well. However, in contrast there was a substantive agreement for vertical disc diameter (ICC = 0.77) in our study. Agreement was not analyzed in their study as they only studied the correlation (r = 0.65).

BL Rao et al. have assessed the disc diameters of small, average and large optic discs estimated by clinician stereo-biomicroscopy and HRT to find an agreement[1]. In their study, the ICC for measurements by clinical method and HRT for vertical disc diameter was 0.487, which was a moderate agreement in contrast to a substantially strong agreement (ICC measurements of 0.77) in the current study when comparing OCT and clinicians' vertical disc diameter values. The mean difference between the clinical and HRT measurements found by them was 0.22 (mm) for vertical disc diameter which seems to be markedly different and unlike our study in which the mean difference between the clinical and OCT measurements for disc diameter was only slightly different (0.04 mm).

Moghimi et al. assessed the optic disc size and CD ratio parameters comparing spectral domain (SD) OCT and HRT evaluated readings in their study. They found that HRT overestimated optic disc area as compared to SD-OCT[17]. However, in our study, the clinician has slightly underestimated the optic disc size as compared to OCT. There is another study, which has shown a poor correlation and agreement for vertical CD ratio measured using HRT-3, OCT and clinical grading[19]. Correlation and agreement of CD ratio in contrast is very good in our study using OCT

and clinical grading.

To mention the merits of our study, we have compared and assessed both the important parameters of optic disc, i.e., vertical optic disc diameter and CD ratio. Secondly, OCT has been utilized in this study to compare both the disc parameters (disc diameter and CD ratio) with clinicians' disc findings. However, OCT has been used for disc topography measures and for its comparison with other methods[20,21,22]. Comparison of OCT, fundus photography and clinicians' stereo bio-microscopy findings for analyzing only the CD ratio parameter for agreement between these methods has also been studied previously by Prof. Meenakshi et al[23]. Furthermore, we have not only used ICC and Bland Altman method for finding an agreement between the two methods but we have also shown correlation between them.

Our study is limited in the fact that we have estimated and assessed the agreement of only vertical disc diameter by the two different methods rather than assessing both horizontal and vertical disc diameters. It is thought that vertical disc diameter is mainly measured in a routine clinical practice and is more important of the two. The patients selected in this study were referred from community opticians to the glaucoma clinics, for assessment but not already diagnosed with it. One of the other limitations of this study was that the optic disc size was not classified in our study and optic discs were not grouped into different categories according to their size. We felt this was not an adequate sample size for that type of descriptive study and this would not have affected the results to a great extent. However, this was a study with an adequate sample size for finding an agreement between the two different methods. The study is also lacking in not providing the diagnosis or a break up of glaucoma diagnosis as the patients were selected from screening clinic. It was considered that this would not reflect greatly and would not change the agreement very much, as this was a head to head comparison of two different methods of same optic discs with same underlying diagnosis if any. The study is limited by utilizing only one clinical observer. Further studies with OCT are required using more observers with different experience in optic disc assessment to explore further and to find a better agreement between the systems. We found that there was a slight difference in the vertical disc diameter values in both methods but more difference was observed for CD ratio values in the two methods. Clinicians underestimated the values in the measurement of both optic disc parameters in our study, perhaps more training is required for measurements and standardization of estimation of optic disc parameters clinically which may improve the agreement further in the future.

CONCLUSION

In summary, the agreement is much greater for both important disc parameters between OCT and clinician methods and clearly it is substantial but still not perfect.

Clinical significance of this study is that the mean estimated values are statistically different in both methods hence we conclude that OCT and clinician measured observations for optic disc measurements are still not interchangeable in clinical practice.

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