www.jmscr.igmpublication.org
Impact Factor 5.84
Index Copernicus Value: 83.27
ISSN (e)-2347-176x ISSN (p) 2455-0450
crossref DOI: https://dx.doi.org/10.18535/jmscr/v5i2.47

IGM Publication
Journal Of Medical Science And Clinical Research
An Official Publication Of IGM Publication

An Observational Study Comparing the Correlation of Vertical Cup Disc Ratio and Disc Damage Likelihood Scale with Visual Field Changes and Central Corneal Thickness in Primary Open Angle Glaucoma Patients

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Abstract
Background: *The current management of primary open angle glaucoma involves cutting edge diagnostic technology but the clinical examination of the optic disc still remains the mainstay of both diagnosis and therapy. The disc damage likelihood scale is a useful tool devised to diagnose and follow up glaucoma patients.*
Purpose: *To compare the Disc Damage Likelihood Scale (DDLS) vis-à-vis the vertical cup disc ratio (VCDR) to document optic disc changes in primary open angle glaucoma (POAG) patients with respect to visual field changes and central corneal thickness (CCT).*
Materials & Methods: *109 eyes of 57 patients attending the Glaucoma clinic at a tertiary care hospital, underwent clinical evaluation, complete medical and ophthalmic history profiling, slit lamp examination, applanation tonometry, Gonioscopy, 78 D biomicroscopy, specular microscopy for CCT and visual field analysis (HFA 24-2 program). The patients' VCDR, DDLS, MD, PSD and CCT were recorded and Pearson's correlation coefficients were calculated for all data sets.*
Results: *57 patients underwent this study with a mean age of 53.74 years. The Pearson's correlation coefficient (r) for VCDR vs MD was 0.603 and that for DDLS vs MD was 0.821. The r for VCDR vs PSD was 0.447 and that for DDLS vs PSD was 0.621. The r for VCDR and DDLS Vs CCT was -0.57 and -0.61 respectively.*
Conclusion: *The DDLS is a better system than the VCDR as it correlates more strongly with visual field indices and CCT. It increases the clinical disc evaluation value for glaucoma patients at no extra cost.*
Keywords-*Disc damage likelihood scale, Vertical cup disc ratio, Automated perimetry, Central corneal thickness.*

Introduction

The glaucomas are a group of disorders characterized by progressive loss of retinal ganglion cells, manifest clinically by loss of optic disc neuroretinal rim tissue, defects in retinal nerve fibre layer and deficits on functional visual field testing. Since the late 1960s, Armaly's [1] vertical cupdisc ratio (VCDR) was the standard method to evaluate and quantify the results of optic disc damage[2]. Gradually, the vertical cupdisc ratio was found to be deficient due to the fact that it did not take into account focal neuroretinal rim loss [3,4,5]. It was also found that the vertical cup-disc ratio was different for smaller cups as they had fewer nerve fibre layers

whereas larger cups had more nerve fibre layers[6]. The third crucial shortcoming was the high inter observer variation while computing the VCDR. These went to prove that Armaly's vertical cupdisc ratio method was not without flaws and was not consistently reproducible for all eyes. Spaeth[7] et al devised a newer disc evaluation system known as the Disc Damage Likelihood Scale (DDLS). This system has been steadily found to be replacing the vertical cup disc ratio method as a tool for documenting optic disc changes in glaucoma patients. This system incorporates parameters such as disc size and rim width in clinical grading of the disc. For the first time, it is possible to group glaucoma patients clinically with an objective score which helps in treatment and prognostication. This system has high inter-observer reproducibility and has been found to correlate strongly with the degree of visual field changes [8,9]. The role of central corneal thickness in predicting glaucomatous damage has been studied in detail in many studies [10,11]. Lower CCT has been found to be associated with more severe visual loss at initial visit than those with greater CCT[12]. This is due to the fact that the cornea and optic disc both occupy scleral potholes in the continuum of cornea, sclera and optic disc lamina. The purpose of this study is to compare the VCDR with the DDLS as tool to quantify glaucomatous damage and correlate them with visual field changes and the central corneal thickness.

Materials and Methods

In a tertiary hospital based prospective case series study, 106 eyes of 53 patients previously established as primary open angle glaucoma patients were studied. The sample size was arrived at based upon existing patient attendance. All consecutive patients satisfying the inclusion criteria and willing to give consent were enrolled during duration of 6 months. Inclusion criteria were best corrected visual acuity of at least 20 / 200 vide Snellen's chart; anterior chamber angles open as demonstrated by Gonioscopy, reliable automated perimetry indices (This was done by performing a Swedish Interactive Threshold Algorithm (S.I.T.A.) standard 24-2 visual field analysis within a month of clinical diagnosis) & informed consent by patient. The exclusion criteria were spherical error of > 5 D or cylindrical error of > 2.5D, any concomitant disease that might have led to raised intra ocular pressure, contact lens wear, optic media opacity that might have prevented fundus exam, history of eye trauma or eye surgery within 3 months and history of neurological diseases. The central corneal thickness was measured in both eyes after informed consent. The readings were taken using ultrasound pachymetry. Three consecutive readings were taken in each eye by a single observer masked to the clinical diagnosis. The mean C.C.T. was obtained by average of the 3 readings taken for both eyes by non parametric tests amongst all patients. The DDLS staging was done by 78D non contact fundus biomicroscopy in a slit lamp. The disc size was noted and classified as small (<1.50 mm), average (1.50 -2.00 mm) and large (> 2.00 mm). The VCDR was documented at first. The neuroretinal rim to disc ratio in whichever axis the rim was thinnest was assessed. In the event of an absence of the neuroretinal rim, the angular distance (in degrees) of absence was measured. The disc was then given a DDLS score of 1-10 based on the DDLS Nomogram13. The visual field analysis reports yielded the MD and PSD values. Correlation between the VCDR with MD & PSD as well as DDLS with MD & PSD was done by Pearson one tailed correlation test. Furthermore, the correlation between CCT with VCDR & DDLS was also done by the same method. The correlation between CCT and MD & PSD were also carried out. All tests were carried out with a confidence interval of 95%. The significance of the nonparametric data was calculated and a p value < 0.05 was taken as significant.

Results

The study group consisted of 109 eyes of 57 patients, 38 of whom were male and 29 were female. 5 eyes were found to have been visual acuity more than 20/200 and were excluded. The mean age was 53.74years (S.D. +/- 8.63 years). The average optic disc size was 2.052 mm (S.D. 0.196 mm). The Pearson's coefficient of correlation (r) for VCDR

with MD was -0.603($p < 0.05$) and that for DDLS with MD was -0.821($p < 0.05$).

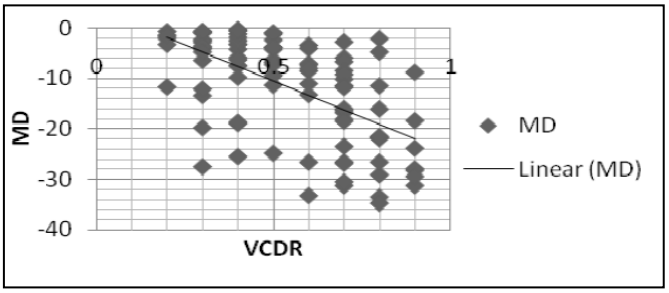

Figure 1a: Scatter plot of VCDR vs. MD (r = -0.603)

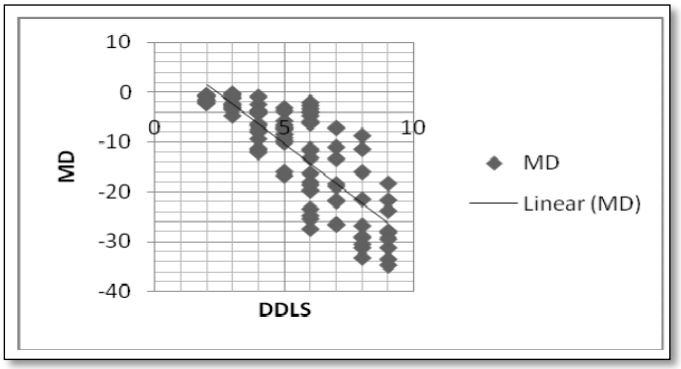

Figure 1b: Scatter plot of DDLS vs. MD (r = -0.821)

The r for VCDR with PSD was 0.447 ($p < 0.05$) and that for DDLS with PSD was 0.621 ($p < 0.05$).

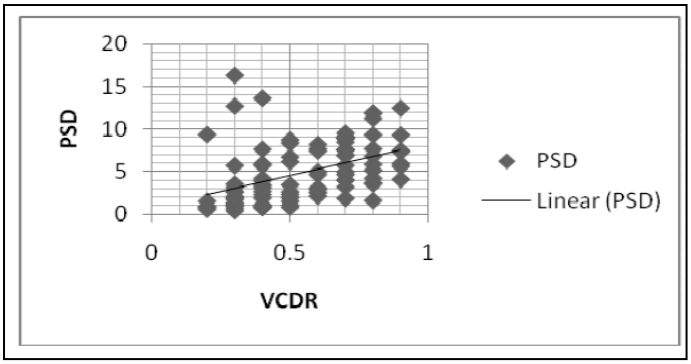

Figure 2a: Scatter plot of VCDR vs. PSD (r = 0.447)

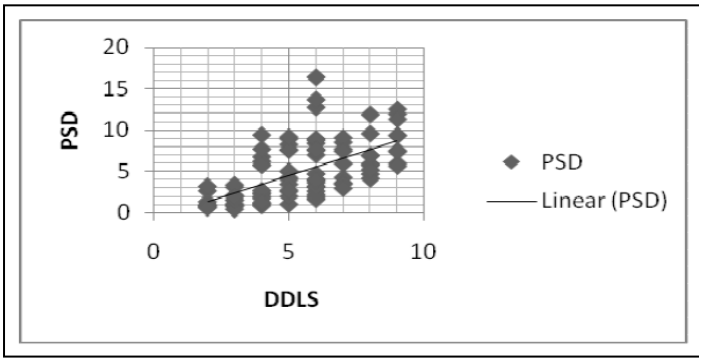

Figure 2b: Scatter plot of DDLS vs. PSD (r = 0.621)

The r value for CCT with MD and PSD was 0.487 ($p < 0.05$) and -0.561($p < 0.05$) respectively. All the findings were consistently reproducible for all disc sizes.

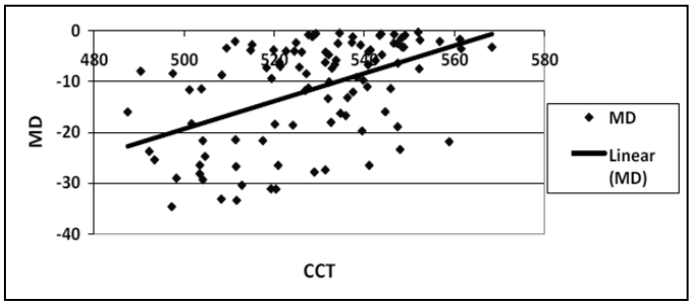

Figure 3a: Scatter plot of CCT vs MD (r = 0.487)

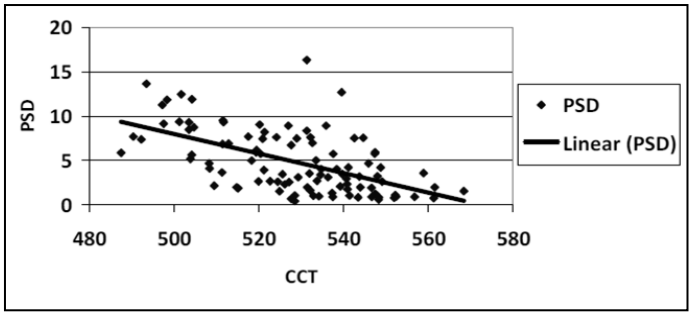

Figure 3b: Scatter plot of CCT vs MD (r = -0.561)

The r for CCT with VCDR & DDLS was -0.551 ($p < 0.05$) and -0.608 ($p < 0.05$) respectively.

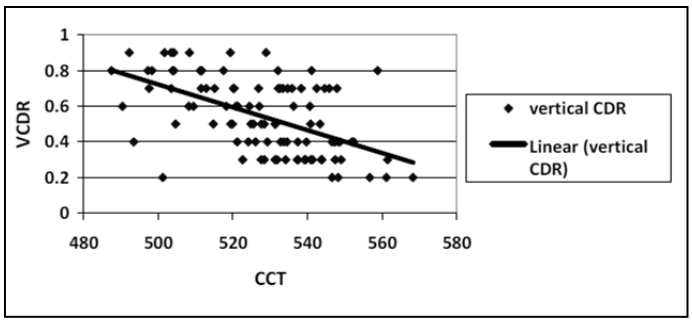

Figure 4a: Scatter plot of CCT vs VCDR (r = -0.551)

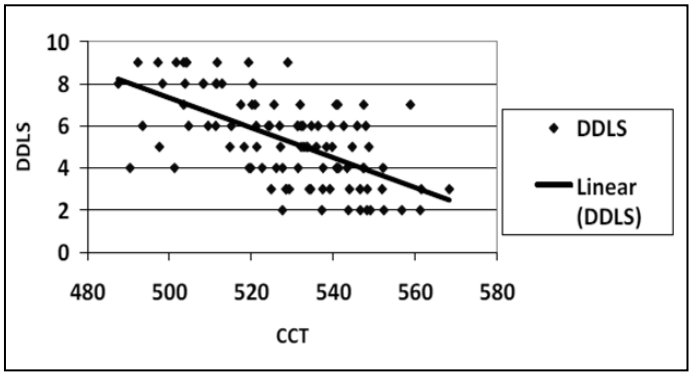

Figure 4b: Scatter plot of CCT vs DDLS (r = -0.608)

Discussion

The observer's ability to correctly evaluate the optic disc changes & to quantify them forms the essence of optic nerve surveillance in glaucoma patients. This study, in large parts, was modelled on the landmark study by Danesh Meyer[14] et al which evaluated the diagnostic strength of the DDLS against the vertical cup disc ratio with respect to visual field loss and HRT. Our study mirrors their findings, e.g. the Pearson's coefficient of correlation for DDLS vs. MD was - 0.62 (for this study r is -0.821), the r value for DDLS vs. PSD in their study was 0.61 (for this study r is 0.621). A recent study by Chandra[15] et al demonstrates results very similar to this study. The study by Bayer 8 et al had found the r for DDLS vs. MD to be -0.695 (r is -0.821 here) and r for DDLS vs. PSD was found to be 0.711 (r is 0.621 here). The correlation coefficient for CCT vs. MD was 0.458 in the study by Papadia[16] et al. In our study the r was 0.486. The r value for CCT vs. PSD was -0.538 whereas this study has an r – 0.561 value of for CCT vs. PSD. In a study by Chauhan[17] et al., the correlation coefficient for CCT vs. MD was 0.294, but for this study, r is 0.486 and the r value for CCT vs. PSD was - 0.313 whereas for this study r is -0.561. Another study by Rogers[18] et al. demonstrated a r value of 0.38 (0.486 here) for CCT vs. MD whereas the r value was -0.31 (-0.561 here) for the correlation between CCT vs. PSD61. The initial versions of the DDLS were designed to replace these fallacies of the VCDR but Spaeth[7] and co workers have since finetuned this into a 10 point scale which takes into account the rim loss and disc size. The system allows easy evaluation, classification and monitoring of glaucoma amongst all patients. For the first time, clinical evaluation achieves greater significance in all the above 3 uses. A DDLS score of 1 to 3 is rarely associated with visual loss, which usually occurs at about a score of 5. For this reason alone we may choose to defer the treatment of such patients and monitor them serially. Unless glaucomatous progression has stabilized, a score of 6 to 10 warrants aggressive treatment. The DDLS has been shown to have excellent inter observer variation though [8,9]. The central corneal thickness was clearly shown to be associated with greater loss of visual field and neuroretinal rim tissue. It may used alone to predict the progression and categorization of glaucoma patients. This study is however hamstrung by limited sample size and lack of follow up amongst patients to assess progression. There are certain limitations of the DDLS. It cannot be applied to anomalous disc or unclassifiable discs, which are best judged individually. The non contiguous loss of rim is also not accounted for and as such makes it less useful. Another issue with the DDLS is that rarely a disc may exhibit sustained damage by having a relentless narrowing of the rim without having an increase in the circumferential extent of rim loss. In this situation the DDLS score will not reflect the actual progression.

Conclusion

This study demonstrates that the DDLS has stronger correlations with visual field loss in glaucoma and reduction of the Central corneal thickness than the previous vertical cup disc ratio system. It is a simple tool and may be routinely applied in diagnosis, monitoring and treatment of glaucoma patients. The DDLS is thus a very reliable method of quantifying optic disc damage in glaucoma. Since it involves drawing the optic disc with meticulous attention to details, it forms a very inexpensive procedure of documentation of glaucomatous change over long periods of follow up, even if newer modalities like GDx, HRT or OCT may not be available.

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