

Comparison between Clinical Evaluations, Stereoscopic Photographic analysis and Confocal Scanning Laser Ophthalmoscope in estimating Cup/Disc Ratio

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Abstract

Objective: To find out the agreement in cup/disc ratio measurements obtained by clinical evaluation, analysis of stereoscopic photographs of optic disc, and Confocal Scanning Laser Ophthalmoscope (Heidelberg Retina Tomograph II Software Version 1.5) in healthy persons and patients with early glaucoma.

Patients and Methods: Thirty healthy persons and thirty patients with early and moderate primary open angle glaucoma were selected on simple random basis. Two expert ophthalmologists evaluated the cup disc ratio with Ophthalmoscope and slit lamp examination with 90 D super field lens. Simultaneous Stereoscopic Optic nerve head photographs were then projected on Topcon Image net system for Cup Disc ratio evaluation. Heidelberg Retina Tomograph II (HRT II) software version 1.5 (Heidelberg Engineering Germany) was performed in all cases and cup disc ratio was obtained. Computer based SPSS program was used for Comparison between these 3 values.

Results: Mean difference between clinical evaluation and automated analysis by HRT II was -0.11 ± 0.03 and -0.15 ± 0.05 for horizontal and vertical cup/disc ratio respectively for ophthalmologist A and -0.09 ± 0.03 and -0.06 ± 0.03 for horizontal and vertical cup/disc ratio respectively. Mean difference between photographic evaluation and automated analysis by HRT II was -0.08 ± 0.02 and -0.15 ± 0.03 for horizontal and vertical cup disc ratio respectively for Ophthalmologist A and 0.05 ± 0.03 and -0.06 ± 0.03 for vertical and horizontal cup disc ratio for Ophthalmologist B.

Conclusion: The automated techniques showed a greater difference in estimating Cup Disc ratio from clinical assessment then from stereoscopic photographs. There was a fair to moderate agreement in vertical cup disc ratio by the three techniques and moderate agreement in horizontal cup disc ratio (JPMA 53:225;2003).

Introduction

Cup disc ratio measurements are one of the most popular methods not only for early detection but also for monitoring progression of glaucoma. Especially when monitoring the treatment effect on glaucoma, accurate and reproducible measurements of disc are necessary.¹ Disc evaluation is

important because clinically detectable glaucomatous damage in the optic disc may precede the onset of white on white visual field defects by several years.²⁻⁴ Clinical evaluation of optic disc morphology can be made with direct ophthalmoscope, slit lamp biomicroscopy with 78D and 90D and with indirect ophthalmoscope.⁵

Clinical evaluation of the optic nerve head is notoriously subject to variation between observers though agreement can be substantial given the right conditions. The development of imaging and measurement techniques has brought the prospect of greater objectivity in the measurement of optic disc features, and therefore better agreement between observers. Confocal Scanning Laser Ophthalmoscope is the most advanced method in current use that provides objective, reproducible, quantitative and three-dimensional analysis of the optic disc. Image analysis on the HRT II has been shown to produce optic disc measurements, such as the estimation of cup/disc area ratio, which are comparable to those made by clinician. Heidelberg Retina Tomograph, software version 1.5, Heidelberg Engineering, Germany, uses a Confocal Scanning Laser Ophthalmoscope (Diode 670 nm) to produce a topographic map of optic nerve head. The light reflected from the surface of retina is imaged. Each image is formed by tiny squares called pixels. Totals of 32 images are taken. The first of these 32 is parallel to the surface of the retina, just anterior to blood vessels as they emerge from the optic cup. Subsequent images are acquired by advancing the focal plane posterior to the lamina cribrosa. A plane is chosen as the reference plane from which the parameters of interest can be calculated. Computer converted three-dimensional reconstruction, can be used to evaluate disc damage in glaucoma.⁶⁻⁸

The HRT software computes a set of stereo metric parameters that quantitatively describe the shape of the optic nerve. Only the vertical and horizontal cup disc ratios were taken from these parameters.

Although more objective measurements can be achieved by Heidelberg retina tomograph II, but it does not mean that this is more accurate in estimating disc measurements. This device uses the clinician induced contour line to define disc margin, whereas in slit lamp examination with 90D lens and in stereoscopic photographs, one evaluates the cup disc ratio by observing the three dimensional shape of cup, including the bending of small blood vessels in the optic disc and the disc border is much more delineable than in tomograph.

Patients and Methods

Thirty glaucomatous patients were selected from glaucoma unit of LRBT Eye and Cancer hospital, Lahore on simple random basis, provided they met the following criteria: age between 20-60 years, spherical Refractive error less than -5.0 or above +5.0 and astigmatic error less than -2.0 or above 2.0, primary open angle on gonioscopy, intraocular pressure more than 22 in at least 3 consecutive times and glaucomatous visual field defects on Humphrey visual field analyser. Normal persons were selected from the

staff of LRBT eye hospital, Lahore and relatives of glaucoma patients on simple random basis provided they had intraocular pressure less than 22 in at least three sittings, normal appearance of optic nerve head and normal visual fields.

All subjects underwent full ophthalmological examination including visual acuity, intraocular pressure, gonioscopy, slit lamp examination with 90D lens, dilated fundus examination with direct and indirect ophthalmoscope, slit lamp examination with 90 D super field lens, stereoscopic photography, and HRT II evaluation of both eyes. Two experienced ophthalmologists evaluated the cup disc ratio both in horizontal and vertical meridian on Haag Striet slit lamp with super field 90D lens.

Simultaneous stereoscopic photographs were taken on telemetric fundus camera (Topcon TRC-SS2, Topcon optical Co., Japan) by lateral shifting of camera. Topcon image net system was used for stereo viewing on colour monitor. Both the ophthalmologists were masked to patient diagnosis and all other clinical evaluation. They were asked to evaluate horizontal and vertical cup disc ratio on the basis of stereo viewing on colour monitor with the help of +10 dioptres lens in front of both eyes.

Heidelberg retina tomograph II (HRT II) software version 1.5.0 developed by Heidelberg Instruments, Heidelberg, Germany, is a Confocal scanning Laser Ophthalmoscope for acquisition and analysis of three-dimensional image of posterior segment of eye. It is an upgraded version of laser tomographic scanner. It scans in three dimensions of the space using a Diode laser (670 nm). To acquire the digital image of optic nerve head a laser beam is focused on the retina and periodically deflected by oscillating mirrors so that a 2 dimensional image of retina is scanned sequentially. If a series of optical images is acquired for different positions of focal plane, the result is a layered three-dimensional image referred as laser scanning tomography. At this point, the only manual step in the analysis process was required, the definition of the optic disc margin. A single experienced operator then drew the contour line with the help of a computer mouse system. This manually marked outline of the disc margin was used to determine and calculate the disc area. In case of peripapillary atrophy, beta zone was used for marking the contour line. This beta zone is significantly associated with both visual field and optic disc glaucomatous damage.

Student's t test was applied with the help of computer based statistical program for social sciences (SPSS). This gave the difference between clinical evaluation and HRT II measurements and stereoscopic photographs verses HRT II measurements.

Results

Mean horizontal and vertical cup/disc ratio measurement were different between the two observers and there was a moderate agreement among the clinical evaluation and stereoscopic photographs and with Heidelberg Retina tomograph II. Difference between the Heidelberg assessment and stereoscopic photographs measurements varied by the ophthalmologists.

Interestingly difference of more than 0.2 between the clinical observation and HRT II findings was found in 14 observations by each ophthalmologist. For horizontal cup disc ratio the difference of more than 0.2 was found in 13.33% by ophthalmologist A and 15% by ophthalmologist B. For vertical cup disc ratio the same difference was 10% by ophthalmologist A and 8.33% by ophthalmologist B.

Table 1. Mean difference between stereoscopic photographic evaluation and automated analysis by HRT II.

Cup/Disc ratio	Ophthalmologist A	Ophthalmologist B
Vertical	-0.08±0.02 P < 0.75	0.05±0.03 P < 0.03
Horizontal	-0.15±0.03 P < 0.001	-0.06±0.03 P < 0.031

Mean ± standard deviation for HRT II assessment of vertical cup disc ratio in normal subjects was 0.243 ± 0.284 and horizontal cup disc ratio was 0.256 ± 0.175 . In glaucoma assessment the cup disc ratio was 0.564 ± 0.324 and for horizontal cup disc ratio was 0.529 ± 0.246 . Mean difference between the photographic and HJRT II assessment are presented in Table 1. Mean difference between the clinical assessment and HRT II assessment are presented in Table 2.

Table 2. Mean difference between clinical evaluation of cup disc ratio and automated analysis by HRT II.

Cup disc ratio	Ophthalmologist A	Ophthalmologist B
Horizontal	-0.15±0.05 P value 0.001	0.25±0.03 P value 0.076
Vertical	-0.11±0.03 P value 0.01	-0.09±0.03 P value 0.043

Difference between photographic and Heidelberg assessment were larger in estimating horizontal then vertical cup disc ratio and also varied by the two ophthalmologists.

Table 3. Difference of more than 0.2 between clinical evaluation by ophthalmologist and HRT II.

Ophthalmologist	Cup/disc Ratio	Discrepancy of more than 2 (number of cases)	Percentage
A	Horizontal	6	10
	Vertical	8	13.33
B	Horizontal	5	8.33
	Vertical	9	15

Measurements of mean ± standard deviations of horizontal cup disc ratio were smaller in Heidelberg assessment than clinical or photographic measurements. No significant difference was found in vertical cup disc ratio and in mean ± standard deviations of glaucomatous verses normal cup disc ratio.

Discussion

The optic disc analysis is the only objective method for detection of early glaucoma.¹¹ The purpose of our study was to find out the reliability of Heidelberg retina tomograph by comparison with the conventional clinical techniques for cup disc ratio measurements.

In our study, it was found that clinical measurement of cup disc ratio by the two ophthalmologists was in the close range of tomographic measurements. However when represented statistically, it was found that there was significant difference between the 2 values in vertical and highly significant difference in horizontal cup disc ratio. No significant difference was found in glaucomatous verses normal optic disc in regard to their cup disc ratio measurements.

Measurements by stereoscopic photographs analysis through Image net system showed better correlation with automated tomograph than with clinical observations. Vertical measurements by one observer showed no significant difference and other one showed significant difference from automated technique. However, the horizontal measurements showed significant to highly significant differences by the two

observers from automated technique. Therefore, the agreement between the observers and automated technique was better in vertical cup disc ratio than horizontal. Heidelberg measurements were smaller than clinical or photographic measurements in 74% cases and were larger in 26% cases. Various studies have compared the HRT measurements with stereoscopic methods. Zangwill et al studied the agreement between clinician measurements and the scanning laser ophthalmoscope when measuring vertical and horizontal cup-disc ratios. They found agreement was moderate to substantial for vertical cup-disc ratios and fair to moderate for horizontal cup-disc ratios in three glaucoma experts.⁶ Hatch et al recently found that agreement between the planimetric method and HRT when measuring area cup-disc ratios was moderate to substantial among the observers.¹² In some other studies, HRT measurements of cup disc ratio were found to be significantly smaller than photographic techniques¹³ and measurements of absolute rim area and rim to disc area were found significantly larger with the HRT compared with planimetry of disc photographs.¹⁴ These findings are comparable with the results of the present study.

There are several explanations to these differences. Clinician measures the cup disc ratio by first considering the disc margin followed by the cup margin from the slope of cup and small vessels angulations at the periphery of cup.¹⁵ In clinical, photographic and automated techniques optic disc border has to be outlined manually. Since the optic disc margin can better be detected clinically and on stereoscopic disc photographs than on HRT II images, a different outlining of the optic disc may partially explain the discrepancy between the two methods. HRT II uses operators defined disc margin (contour line) and disc area is total area enclosed by the contour line while the cup area (mm²) as the area enclosed by the contour line and located beneath the reference plane (reference plane is an arbitrary plane 0.32 mm below the reference ring).

There was better agreement for vertical cup disc ratio than horizontal in both comparisons. Reason of this difference is that there is difficulty in measurements of horizontal cup disc ratio because of obscuration by blood vessels. Blood vessel trunk present at the cup area may be the reason of another finding that tomographic measurements were smaller than the clinical. Another reason that can explain the discrepancy among the different technique is that the tomograph measures parts of the central retinal vessel trunk as if it belongs to the neuroretinal rim even if there is no nerve fibre tissue beneath the vessels. It does not distinguish between different types of tissue. Since the retinal vessels of the optic nerve head cross the reference plane, they are partially included in the measurement of the neuroretinal rim area. In contrast, clinically and photographically retinal vessels are

considered to belong to the neuroretinal rim only, if neuroretinal rim tissue with retinal ganglion axons is underlying them. Other researchers showed similar results.^{16,17}

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