Plannimetric Analysis of Optic Disc and Cup

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Abstract

Glaucoma is a group of diseases, which damage eye's optic nerve that will lead to blindness. Open-angle glaucoma, the most common form of glaucoma, is one of the leading causes of blindness. Glaucoma usually has no early symptoms, and by the time people experience problems with their vision, they usually have lost a significant amount of their sight. To study the cause of open-angle glaucoma is made a major important, by which the patients who are suffering from open-angle glaucoma can be identified with the tests made.

Fundus (retina) images of the patients were grabbed using Nidek/Ziess cameras. The resulting slides were scanned using Nikon slide scanner and ingested into a Personal Computer. Planimetry was carried out using specially developed software by us. The data from the study shows that the Optic Disc size in Ocular HyperTension group is smaller as compared to normal groups.

Introduction

Increased pressure inside the eye is an important cause of open-angle glaucoma. In the front of the eye is a space called the anterior chamber. A clear fluid flows continuously in and out of this space and nourishes nearby tissues. The fluid leaves the anterior chamber at the angle where the cornea and iris meet. When the fluid reaches the angle, it flows through a spongy meshwork, like a drain, and leaves the eye.

Open-angle glaucoma gets its name because the angle that allows fluid to drain out of the anterior chamber is open. However, for unknown reasons, the fluid passes too slowly through the meshwork drain. As the fluid builds up, the pressure inside the eye rises. Elevated eye pressure can damage the optic nerve; a healthy optic nerve is necessary for good vision. When the optic nerve is damaged from increased pressure, glaucoma -- and vision loss -- are the result.

At first, open-angle glaucoma has no symptoms. People are not aware that glaucoma is affecting their vision, and there is no pain. When glaucoma remains untreated, people may notice that although they see things clearly in front of them, they miss objects to the side and out of the corner of their eye. Without treatment, people with glaucoma may find that they have no side vision. Over time, the remaining vision may decrease until there is no vision left.

Signs and Symptoms

There are at least three definitive signs:

- elevated intraocular pressure (approximately 21mm Hg or more)
- enlargement of the optic cup
- repeatable field loss.

Other possible signs include nerve fiber layer dropout, notching of the neuroretinal rim at the inferior or superior poles, and splinter hemorrhages adjacent to the optic disc.

The size of optic cup varies physiologically with the size of optic disc, and there is a large variation in the size of optic disc in normal population. It has been reported that the largest disc size is size times bigger than the smallest disc size. This variation in disc size means that large cups may be normal if the disc is large, and cups should be small or may even absent if disc is small.

The cup to disc ratio varies from 0.0 to 0.87. The ability of the cup to disc ratio with disc size to detect glaucoma cases is greater in smaller optic discs than in larger ones.

You can outline the Disc and Cup on the first (baseline) and subsequent images. Traditional Vertical and Horizontal Cup/Disc ratios, Area and Perimeter ratios are calculated automatically. Rim to disc ratio and percentage of redness at upper temporal, lower temporal, nasal, temporal of the retina are also brought out with this specially developed software. With above results one can identify whether the eye is a normal eye or suffering from open-angle glaucoma.

Traditional Cup/Disc ratios provide a widely understood, if only approximate, indicator of the state of a disc. For better measure of the health of an optic disc, the calculation of extent of Rim remaining is very useful.

Materials and Methods

42 patients with POAG, 26 with OHT and 30 normal subjects were enrolled in the study. A complete ophthalmic examination including assessment of refractive error, slitlamp evaluation, applanation tonometry, gonioscopy, and stereo-disc evalation with Volk 78 D lens was carried out in all subjects.

All patients underwent keratometry, axial length determination by A-scan biometry and automated perimetry with the Humphrey visual field analyzer using 30-2 program, and the disc photography with Nidek 3dx NM. In 23 eyes disc photography was done with the Zeiss fundus camera. Only one randomly chosen eye of each subject was included in the study.

POAG was defined as glaucomatous disc and visual field changes with raised or normal IOP and open angles. OHT was defined as IOP of more than 21 mm Hg on applanation tonometry with normal visual field and disc morphology. Normal controls and normal discs, normal visual fields, and intraocular pressure of 21 mm Hg.

The optic disc image obtained on a 35mm colour slide was digitized using a Nikon coolscan. Planimety was carried out using software developed by us, which included Littmann correction. The magnification factor for the Nidek camera was taken as 2.6 and that for the Ziess camera was 1.37. The q value was determined from the axial length or corneal curvature, and the refractive error by a regression equation from the graphs provided by Littmann. This is a measure of the magnification of the retinal image produced by the optics of the eye. The horizontal and the vertical diameters were measured. The optic disc margin was manually outlined by a series of straight lines joining each other in a polygon. The area of the polygon was calculated as the sum of the areas of the constituent triangles. The mean and standard deviation of each of these parameters for the three groups were compared by Analysis of Variance (ANOVA).

Results

The mean, standard deviation and 95 % confidence limits of the vertical and horizontal disc diameters and the disc area are shown in Table 1. The ANOVA shows the difference in all the parameters for the three groups to be significant. The post-hoc analysis following the ANOVA revealed that for the disc area the difference between OHT and POAG as well as normal subjects was significant at $p<0.0001$. The horizontal disc diameter was significantly smaller in OHT as compared to both POAG ($p<0.0036$) and normal subjects ($p<0.0001$). Similarly, the vertical disc diameter also was significantly smaller in OHT as compared to POAG ($p<0.014$) and normal subjects($p<0.0003$). There was no statistically significant difference for any of the parameters between the POAG and normal subjects.

Table 1

Planimetry of optic disc in OHT, POAG, and normals

	VDD (mm) (95% C.I)	HDD(mm) (95% C.I)	Disc area(mm x mm) (95% C.I)
Normals N=30	4.28 +/- 0.81 (3.99-4.57)	4.36 +/- 0.72 (4.10-4.60)	12.11 +/- 2.84 (11.90-13.13)
POAG N=42	4.05 +/- 1.26 (3.67-4.43)	4.07 +/- 1.17 (3.71-4.43)	12.77 +/- 2.87 (11.91-13.63)
OHT N=42	3.46 +/- 0.72 (3.19-3.73)	3.46 +/- 0.36 (3.31-3.6)	9.47 +/- 1.09 (9.04-9.9)
p-value	0.0071	<0.0001	<0.0001

OHT is ocular Hypertension, POAG is primary open angle glaucoma, VDD is vertical disc diameter, HDD is horizontal disc diameter

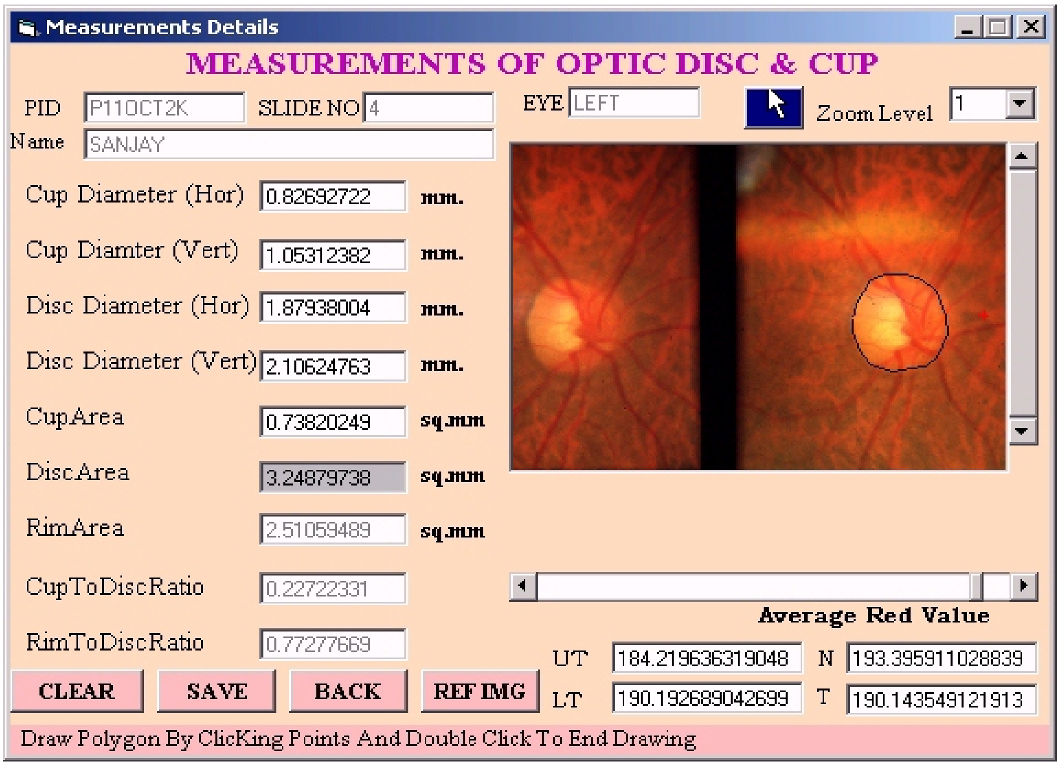
Though the disc parameters were significantly smaller in the OHT group as compared to the POAG and the normal subjects, the absolute values for all the parameters were abnormally high. To understand the reason for this we looked at the disc parameters in 16 normal and 7 ocular hypertensive eyes that had disc photographs with both Nidek and Ziess cameras. The mean and standard deviation of horizontal and vertical disc diameters and the disc area for these 23 eyes are shown in table 2. The diameters were larger by a factor of 1.8 and the area was greater by a factor of 3.3 with the Nidek camera as compared to the Zeiss camera.

Table 2

N=23	VDD (mm)	HDD(mm)	Disc area(mm x mm)
Zeiss	2.11 +/- 0.14	1.97 +/- 0.17	3.17 +/- 0.5
Nidek	3.91 +/- 0.28	3.53 +/- 0.36	10.49 +/- 0.5

VDD is vertical disc diameter, HDD is horizontal disc diameter

The figure given below is one of the window captured from the software which is developed by us, calculated disc diameter (vertical, horizontal) disc area etc. The eye images are captured by Zeiss camera.



Discussion

A series of editorials debated the need to treat these patients but agreed on the definition as raised IOP with open angle and normal optic disc and visual field. Over time, in an effort to more closely identify the subset of OHT patients who are at risk of developing a field loss, patients with ophthalmoscopic features of disc damage with normal visual fields have been categorized as OHT by some authors while others still use normal disc appearance as a part of the definition of OHT. Since it is known that optic nerve head and nerve fibre layer changes precede visual field damage, we have included in our OHT cohort only eyes with raised IOP with no disc changes suggestive of glaucoma and normal visual fields.

The OHT conversion rate to POAG is known to be very small. This is probably because OHT comprises eyes that belong to more than one subgroup. One group would consist of eyes that have no damage and probably are not a risk of developing damage in future, some of these eyes in fact may have a falsely recorded high IOP that is secondary to increased corneal thickness. The other group of eyes may have a tendency to develop future damage or have visual damage that cannot be identified by conventional automated perimetry; these could be termed ‘pre-perimetric’ glaucoma. This latter group may have subtle optic nerve head changes either at the time of evaluation or would develop these changes in due course depending on the time lag between the optic nerve head anatomical changes and the appearance of visual field changes on standard automated perimety. Because OHT is defined as eyes with no damage we feel that the latter group of “pre-perimetric” glaucomatous eyes should not be included in OHT.

Study data

Using magnification-corrected morphometry and defining OHT as increased IOP with no disc or field changes suggestive of glaucoma, we found that the optic nerve head area (in mm*mm) in OHT (9.47, 95 % CI=9.04-9.9) is significantly smaller ($p<0.0001$) than in both normals (12.11, 95 % CI = 11.09-13.14) and POAG (12.77, 95% CI = 11.91-13.63). Optic disc size was found to be smaller in OHT in another study, but did not reach statistical significance. In this study OHT eyes did not have disc changes suggestive of glaucoma. This brings up the possibility that small disc are resistant to IOP induced damage or that in these visual field changes take a longer time to manifest. The findings that smaller discs are more resistant to IOP-related damage is indirectly supported by the data from the Baltimore Eye Survey. This study showed that blacks have larger optic discs as compared to whites, and that the decrease in neuroretinal rim area in relation to increasing IOP is greater in blacks as compared to whites. While this difference could be related to racial factors, the disc size could be a contributing factor.

Study Limitations

The abnormally large measurements recorded with the Nidek camera as opposed to the Ziess is a concern with the data. An error in the magnification factor of 2.6 was considered but the manufacturer refuted this possibility. This error will not affect the results because the study seeks to compare the optic nerve head size in OHT with that in POAG and normals. Since the measurement in all groups is subjected to the same factor the relative size in OHT as compared to POAG and normals is still significant.

The other limitation of this study could be a bias in the sample towards specifically taking small optic discs into the OHT group as eyes with increased cup-disc ratio, raised IOP and no visual field changes were not included in the cohort of OHT. On the other hand studies that include eyes with disc changes suggestive of glaucoma with no field changes into OHT could be including 'pre-perimetric' glaucomas into OHT.

It would be useful to include in OHT eyes with cup-to-disc ratios normal for the size of the disc in the given eye. To the best of our knowledge such data have not been reported. In conclusion, the data from the present study show that the optic disc size in OHT is smaller than that in POAG and normals.

Conclusion

Hyper Tension patients need not necessarily suffer from glaucoma.

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