# SPECTRUM OF OPTIC DISC CHANGES IN PRIMARY OPEN ANGLE GLAUCOMA

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## ABSTRACT

**Objective:** To find out the patterns the optic disc changes associated with primary open angle glaucoma (POAG).

**Methodology**: This descriptive study was conducted at Ophthalmology department, Hayatabad Medical Complex Peshawar from 1st January to 31st December 2009. All patients with diagnosed POAG, above the age of 30 years, having no lens or media opacity and ocular co-morbidity, were examined thoroughly for patterns of optic disc changes associated with POAG. Frequencies and percentages of the contour of neuroretinal rim, appearance of nerve fiber layer, presence of optic disc hemorrhages, colour of optic nerve head was noted. Descriptive statistics for disc were calculated for Vertical disc diameter (VDD), Cup/disc ratio (CDR), and Rim Disc Ratio (RDR).-

**Results:** Two hundred patients with POAG were included. Diffuse thinning and localized notching in the neuroretinal rim was noted in 188 (94%) and 86 (43%) patients, respectively. Optic disc hemorrhage, Optic disc pallor and Optic disc atrophy was seen in 80 (40%), 127 (63.5%) and 15 (7.5%) cases, respectively.

Mean VDD was 1.76mm in both right and left eyes. Mean vertical and horizontal CDR was 0.73 and 0.57 in the right and 0.765 and 0.611 in the left eye, respectively. Mean vertical and horizontal RDR was 0.451 and 0.543 in the right and 0.368 and 0.486 in the left eyes, respectively.

**Conclusion:** Majority of the patients showed changes in measurements of neuroretinal rim, so emphasis should be placed on the examination of neuroretinal rim in all patients of POAG.

**Key words:** Primary Open Angle Glaucoma, Optic disc, Neuroretinal rim

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## INTRODUCTION

Glaucoma, a specific form of optic neuropathy, causing irreversible blindness, is the third most common cause of blindness in the world[1]. Quigley and Broman have estimated that glaucoma will afflict 60.5 million people in the year 2010[2]. The prevalence of blindness in Pakistan is 2.7% (1,140,000 blind adults) based on National health Survey of 2003[3]. Glaucoma was found to be the fourth most common cause of blindness in Pakistan[3]. In Pakistan Primary open angle glaucoma (POAG) is the most common type[4]. POAG is the predominant form of glaucoma in Asian and Western countries[1, 5-8].

The diagnosis of Primary open angle glaucoma (POAG) is traditionally based on the triad of increased intraocular pressure (IOP), Visual field changes and Optic nerve head changes[9]. Assessment of optic nerve head appearance can be divided into two parts, qualitative which includes evaluation of the contour of the neuro-retinal rim, appearance of the nerve fiber layer (NFL), presence of optic disc hemorrhages, extent of para-papillary atrophy and colour of the optic nerve head, while quantitative findings are Optic disc size (vertical disc diameter VDD), Cup disc ratio (CDR), and Rim disc ratio (RDR)[10-12].

Stereoscopic assessment of optic nerve head is done by indirect ophthalmoscopy, central part of the goniolens, Hruby lens and Volk 90, 78 and 60D lenses[13]. Indirect ophthalmoscopy is appropriate for assessment of the optic disc in glaucoma, while the 78D lens provides a good balance between the field of view and magnification[9, 13-15]. Slit-lamp biomicroscopy is an easy, rapid and inexpensive method for estimating the optic disc size and changes in POAG[16].

The aim of this study is to enlist the morphological changes of the optic nerve head in our local population diagnosed as having POAG. Heidelberg Retina Tomograph and Ocular coherence tomography are the latest and objective methods for the quantitative assessment of optic nerve head but at the time of the study were not available in the department.

## METHODOLOGY

This descriptive study (case series) was carried out at Ophthalmology department from January1st 2009 to December 31st 2009.

Patients above the age of 30 years, with diagnosed primary open angle glaucoma (old and new cases), and having no lens or media opacity were included. Patients with a history of ocular trauma and ocular co-morbidity and patients with secondary glaucoma and angle closure glaucoma were excluded.

A Performa was designed and completed for all the patients. After taking consent, name, age, gender, occupation, address and date of examination was noted. A detailed history about the visual complaints such as pain, redness, haloes, alteration and loss of vision was obtained. Past ophthalmic history of any ocular trauma, ocular surgery and laser therapy was noted. Family history of glaucoma, history of any systemic diseases and medication history about the use of steroids, glaucoma medications, and any systemic medications was documented.

A thorough ocular examination was carried out including Visual acuity examination (aided and unaided), pupillary reactions, extra ocular motility, intraocular pressure (IOP) check, gonioscopy and detailed anterior and posterior segment examination of both eyes.

Optic disc examination included evaluation of qualitative changes like contour of the neuroretinal rim, presence of optic disc hemorrhages, appearance of nerve fiber layer (NFL) and optic disc color and quantitative morphometric analysis of optic nerve head e.g. determination of optic disc size (vertical disc diameter ,VDD ), cup/disc ratio (CDR), both horizontal and vertical and rim disc diameter (RDD) both horizontal and vertical with slit lamp biomicroscopy using 78D(Volk) indirect condensing lens.

Measurement of the optic disc diameter (vertical) was done by adjusting vertical beam of slit lamp with vertical edges of optic disc, and then vertical cup diameter was assessed. Then the beam of slit lamp was adjusted horizontally by turning it to 180 degree and same procedure was done for the measurement of horizontal disc and cup diameters Vertical cup/disc ratio, horizontal cup/disc ratio, vertical rim/disc ratio and horizontal rim/disc ratio were calculated. Contour of the neuroretinal rim was assessed for any localized notching in any specific quadrant or diffuse loss. The presence or absence of any optic disc hemorrhage along with the location was noted. Nerve fiber layer (NFL) defects were checked two disc diameters from optic disc with red free (green) slit lamp beam for any localized defects like slit or wedge defects and if there was generalized defects they were noted.

Data was analyzed by SPSS version 10. Frequencies and percentages of contour of neuroretinal rim, appearance of nerve fiber layer, presence of optic disc hemorrhages and color of optic nerve head was noted. Means, medians, modes and standard deviation for optic disc size (VDD), cup/disc ratio (CDR), rim disc ratio (RDR) was calculated.

## RESULTS

A total of 200 patients with POAG were included in this study, out of which 106 were males and 94 were females. Age range was from 30-80 years and majority of the patients fall in the age range of 40-60 years (66%) with mean age of 55 ±8. The diffuse thinning in the contour of neuroretinal rim was noted in 188 (94%) patients and localized notching in the contour of the neuroretinal rim was seen in 86 (43%) patients. One hundred and fourteen (57%) eyes did not show localized notching.

Optic disc hemorrhage was noted in 80 (40%) patients, out of which 46 (23%) were in supratemporal quadrant (STQ) and 34(17%) in the infratemporal quadrant (ITQ).

**Table1: Optic Disc Changes in Primary Open Angle Glaucoma**

| | Vertical disc diameter | | Cup/Disc ratio (vertical) | | Cup/Disc ratio (Horizontal) | | Rim/Disc ratio (vertical) | | Rim/Disc ratio (Horizontal | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Right eye | Left eye | Right eye | Left eye | Right eye | Left eye | Right eye | Left eye | Right eye | Left eye |
| Mean | 1.763 | 1.762 | 0.731 | 0.765 | 0.575 | 0.611 | 0.451 | 0.368 | 0.543 | 0.468 |
| Median | 1.800 | 1.800 | 0.800 | 0.800 | 0.550 | 0.600 | 0.400 | 0.300 | 0.600 | 0.400 |
| Mode | 1.8 | 1.8 | 0.9 | 0.8 | 0.4 | 0.7 | 0.2 | 0.2 | 0.3 | 0.3 |
| Standard Deviation | 0.219 | 0.220 | 0.203 | 0.71 | 0.233 | 0.191 | 0.303 | 0.263 | 0.282 | 0.264 |

One hundred and twenty patients (60%) did not show optic disc hemorrhage. Optic disc color was noted in all patients. It was normal in 58(29%) patients; disc pallor was seen in 127(63.5%) patients. Optic disc atrophy was observed in 15(7.5%) cases, Appearance of the peri-papillary nerve fiber layer (NFL) was observed in all patients. Diffuse thinning of the NFL was seen in 62 (31%) cases. It was not observed in 68 (34%) patients. Localized notching of the NFL was seen in the left eye of 38 patients. It was not observed in 84 patients. Vertical disc diameter in right eyes were mean 1.763mm, while in left eyes vertical disc diameter was mean 1.762mm (Table 1). In right eyes vertical mean cup disc ratio (CDR) was 0.731, while in left eyes vertical CDR mean 0.765 (Table 1). In right eyes horizontal mean CDR 0.575, while in left eyes horizontal mean CDR0.611 (Table 1). In right eyes vertical mean RDR (Rim disc ratio) 0.451, while in left eyes vertical mean RDR (Rim disc ratio) was 0.368 (Table 1). In right eyes horizontal RDR mean 0.543, while in left eyes horizontal RDR mean 0.486 (Table 1).

## DISCUSSION

The aim of this study is to describe the morphological changes of the Optic nerve head in Glaucoma, in an attempt to assist in the diagnosis of Primary open angle Glaucoma. The estimation of the optic disc size and other glaucomatous changes is dependent on the instrument and the method used for assessment[17]. The method of estimating optic nerve head with 78D is a more reproducible and cost effective method of optic disc estimation in clinical and screening assessment[14]. Measuring the disc size by indirect ophthalmoscopy is also possible[15]. As 78D lens is used in this study, the comparison with studies done by latest technologies is very relevant. The slit lamp biomicroscopic measurement of the optic disc diameter using a high power positive lens, shows an acceptable intra observer and inter observer variability in routine clinical work[18].

The diffuse thinning in the contour of the neuroretinal rim was seen in 31% of cases with localized notching in the contour of the neuroretinal rim was seen in 86 (43%) patients out of which 16% were involving superior quadrant and 27% were involving the inferior temporal quadrant.

Another study shows that the mean rates of rim-area loss were 1.7%/y in eyes with initially normal fields and 2.1%/y in eyes with initial field loss[19].

Loss of axons in glaucoma is reflected as abnormalities of the neuroretinal rim. Normally the rim is widest in the inferior temporal sector, followed by the superior temporal sector, the nasal and the temporal horizontal sector[20]. Since localized field defects restricted to one hemisphere are an early sign of glaucoma, stereoscopic examination of the neuroretinal rim in the superior and inferior poles comparing fully their thickness, pallor and notching can aid in the diagnosis of very early glaucomatous damage[21]. The focal nerve fiber loss in early glaucoma is more subtle and requires close observation to detect. In early glaucoma the inferior rim is usually affected first, with the superior rim a close second. The next tissue to be damaged is typically the temporal rim, with the nasal rim the last affected[21, 22]. The same findings were noted in this study as majority defects (27%) located in the inferior quadrant and 16% localized to the superior temporal quadrant. The rim tissue is often the first area to show changes in glaucoma and must be examined very critically during an optic nerve head evaluation[20].

In study by Fazio et al in open angle glaucoma, the neuroretinal rim area was negatively correlated with the cup-disc ratio and the disc volume. Total field loss was positively correlated with the cup-disc ratio and the disc volume and negatively correlated with the neuroretinal rim area. Eyes with low-tension glaucoma showed a negative correlation between neuroretinal rim area and cup-disc ratio, and between total field loss and rim area[23].

In this study a total of 80 patients (40%) were having optic disc hemorrhages, out of which forty six (23%) patients had hemorrhage in the supratemporal quadrant and 34(17%) patients had hemorrhage in the infratemporal quadrant. Yoo et al found in their study that 75% had optic disc hemorrhages in Normal tension glaucoma patients, which is considered to be a variant of Primary open angle glaucoma. They also reported that the two most frequent sectors for optic disc hemorrhages are the supratemporal quadrant and the infratemporal quadrants[24]. The findings of this study are in agreement with the finding of their study.

According to the Ocular hypertension treatment study (OHTS), the incidence of Primary open angle glaucoma in patients with optic disc hemorrhage was 14% compared, compared with 5% in those without optic disc hemorrhage[25]. A small disc hemorrhage, known as splinter or drance hemorrhage, is commonly associated with Normal tension glaucoma and it is very rare for them to occur in the normal population. Splinter hemorrhages have been shown to precede nerve fiber layer and visual field changes in some patients[26].

In a study by Healey et al the overall prevalence in subjects with open-angle glaucoma was 13.8% (8% in high-pressure glaucoma and 25% in low-pressure glaucoma). Although the strong association of disc hemorrhage with open-angle glaucoma was confirmed (particularly low-pressure glaucoma), most disc hemorrhages (70%) were found in participants without definite signs of glaucoma[27].

The frequency of hemorrhages was 6.3% in nor-

mal-pressure glaucoma, 4.9% in primary open-angle glaucoma, and 3.1% in secondary open-angle glaucoma. They were correlated with localized retinal nerve fiber layer defects, neuroretinal rim notches, and circumscribed perimetric loss. These characteristics imply the pathogenetic and diagnostic importance of disk hemorrhages for the detection of glaucoma[28].

In this study there were 66% patients with diffuse thinning in the appearance of nerve fiber layer (NFL), while 58% were having localized defects. Nerve fiber layer atrophy is associated with a high risk for visual field loss. Localized defects are the easiest to detect and may be very specific to differentiate early glaucoma from normal eyes, while they occur in 10 to 20% of ocular hypertensive eyes, they must be looked for in every glaucoma suspect as the high specificity is clinically useful in identifying patients with impending or established perimetric loss[29]. In a study by Xia et al they found defect types of retinal nerve fiber layer: RNFL diffuse loss and local defect ratio were 53.19% and 4.26% in Primary open angle glaucoma, respectively, while were 21.05% and 55.26% in Normal tension glaucoma respectively[30]. Retinal NFL thickness is among the most efficient parameter for the diagnosis and progression of glaucoma. Our study is also supporting the above study that RNFL is an important variable in the assessment of glaucoma and should be examined with great conscious in suspected cases.

According to study mean nerve fiber layer thickness in normal individual by Optical coherence tomography is 114.2 +/- 6.0 microns as compared nerve fiber layer thickness in patients having POAG where mean is 64.6 +/- 28.8 microns[31].

In one study the glaucoma group, superior and inferior quadrant thicknesses and average RNFL thickness significantly correlated with the visual field index (superior quadrant thickness, r = 0.36; inferior quadrant thickness, r = 0.32; average RNLF thickness, r = 0.35; $p < 0.05$) [32].

Another study shows that the RNFL of glaucomatous patients showed local thinness or defect, diffuse thinness or combination of the above two types. The mean RNFL thickness of normal group was (90.1 +/- 10.8) micrometer, (140.4 +/- 10.5) micrometer, (85.2 +/- 14.0) micrometer, (140.4 +/- 9.7) micrometer and (114.2 +/- 6.0) micrometer, of glaucomatous group was (56.0 +/- 31.0) micrometer, (81.0 +/- 36.3) micrometer, (47.1 +/- 27.5) micrometer, (73.4 +/- 38.4) micrometer and (64.6 +/- 28.8) micrometer in temporal, superior, nasal, inferior quadrant and the whole area, respectively[33].

In this study the mean vertical optic disc diameter was 1.76mm, median 1.8mm with a SD of 0.219. The normal optic nerve diameter varies in size from 1.2mm to 2.5mm with the average being 1.8mm vertically and 1.7mm horizontally. The area of the disc varies in normal patients from 0.92 to 5.54 square millimeters with African-Americans having a significantly larger disc area than Caucasians[34]. Mean disc area measurement in the white population range from 1.70mm$^2$ to 2.89mm$^2$, [35] .It has been suggested that patients with larger optic disc size may have an increased susceptibility to glaucoma. However a recent study by Jonas et al comparing the visual field loss to the optic disc size for each eye in Caucasian patients with less than 8D of myopia found no correlation between the size of the optic nerve and the likelihood of visual field loss[36]. Nevertheless, the importance of a large or small cup disc ratio can only be determined when considered in the context of the size of the optic nerve head.

In this study the Vertical mean Cup disc ratio (CDR) was 0.731, median 0.800, mode 0.9 with SD of 0.203, while horizontal mean CDR was 0.575, median 0.550, mode 0.4 with SD of 0.233. There is large variation in cup disc ratios within any given population. Jones et al have performed several ground breaking studies on the morphometry of the optic nerve head and the importance of considering disc size in glaucoma diagnosis. According to Jones, cup disc ratio can range from 0.0 to 0.9 in healthy population, and there is considerable overlap between normal and glaucomatous eyes[20]. In a study of 4877 normal individuals, the average horizontal CDR was found to be 0.47 in Caucasians and 0.57 in African-Americans[37]. Another study supports these results with averages of 0.51 in the horizontal and 0.43 in the vertical meridian[38]. Our study is supporting the observation that VCDR was larger than HCDR. The importance of assessing cup/disc ratio corrected for disc size has extensively been studied by Jonas and co workers[11]. They as well as many studies showed that the vertical cup disc ratio corrected for disc size had the highest diagnostic power for separating normal subjects from pre perimetric glaucoma patients. The estimation of the vertical CDR is one of the most frequently performed clinical methods for assessment of the optic disc in glaucoma diagnosis and follow-up[39].

In this study the mean vertical rim disc ratio (RDR) in right eyes is 0.4, with SD 0.303, while mean vertical rim disc ratio in left eyes is 0.3 with the SD of 0.263. The mean horizontal rim disc ratio (RDR) in right eyes is 0.5, with SD 0.282, while mean horizontal rim disc ratio in left eyes is 0.4 with the SD of 0.264. The number of retinal nerve fiber in healthy eyes varies between individuals and ranges from 750,000 to 1,500,000 million[40]. The intrapapillary retinal nerve fibers form the neuroretinal rim. There is consistent evidence, regardless of the measurement technique that rim area increases with increasing disc size[41]. Some histological studies have reported a positive correlation between disc size and the number of nerve fibers, while other studies have not

confirmed this relationship. Quigley et al found that the number of nerve fibers increased linearly with increasing disc size in monkey eyes[42]. This association was subsequently confirmed by Jonas who demonstrated that in humans, large discs have more nerve fibers as compared to small discs[11]. However, conflicting data were reported by Mikelberg and colleagues. In their study they found no correlation between the disc size and the number of nerve fibers[43]. These contradictory results among studies may be explained at least in part by differences in the methodology used for estimating disc size (histological vs. imaging technique), species and the number of eyes examined. All of the above studies supported that rim/disc ratio measurement is relevant regarding primary open angle glaucoma diagnosis and progression. Our study is also supporting that the rim measurement is an important variable in the assessment of primary open angle glaucoma.

## CONCLUSION

Majority of the patients showed changes in measurements of neuroretinal rim, so a lot of emphasis should be placed on the examination of neuroretinal rim in all patients of primary open angle glaucoma.

## LIMITATION

The major study limitation was the non-availability of facilities of Optical Coherence Tomography (OCT) and Heidelberg Retinal Tomograph (HRT) which are the new, modern and sophisticated tools for optic nerve head assessment in POAG. Further studies should be conducted to assess these changes with these modern technologies.

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## CONTRIBUTORS

SI conceived the idea, planned and wrote the manuscript of the study. ZK and MA helped in the data analysis and write up of the manuscript. NS supervised the study. All the authors contributed significantly to the research that resulted in the submitted manuscript.