



## Original Research Article

# Correlation between optic disc changes and visual field changes in glaucoma suspects: A clinical study

Authors

**Dr Nivedita Choudhury<sup>1</sup>, Dr Dinesh Kumar Bhagat<sup>2\*</sup>, Dr Anirban Chakrabarti<sup>3</sup>**

<sup>1</sup>Assistant Professor, Department of Ophthalmology, Mata Gujri Memorial Medical College & Lions Seva Kendra Hospital, Kishanganj, Bihar- 855107, India

<sup>2</sup>Assistant Professor, Department of Ophthalmology, Mata Gujri Memorial Medical College & Lions Seva Kendra Hospital, Kishanganj, Bihar- 855107, India

<sup>3</sup>Associate Professor, Department of Psychiatry, Mata Gujri Memorial Medical College & Lions Seva Kendra Hospital, Kishanganj, Bihar- 855107, India

\*Corresponding Author

**Dr Dinesh Kumar Bhagat**

Assistant Professor, Department of Ophthalmology, Mata Gujri Memorial Medical College & Lions Seva Kendra Hospital, Kishanganj, Bihar- 855107, India

## Abstract

**Background:** This study was done to identify a group of POAG suspects from the patients attending the O.P.D and to monitor them periodically for a period of one year for detecting early signs of glaucomatous damage of ONH and glaucomatous VFDs.

**Materials & Methods:** The present study was carried out in Mala Gujri Memorial Medical College, Department of Ophthalmology, Kishanganj from July 15<sup>th</sup>, 2016 to June 14<sup>th</sup>, 2017. About 50 glaucoma suspects were selected for the study from the patients attending the O.P.D. The selection was made on the basis of findings of gonioscopy, applanation tonometry, direct ophthalmoscopy, slit lamp biomicroscopy, stereoscopic visualization of ONH by +90D lens, automated perimetry by Humphrey Field analyzer (central 30-2 test) and fundus photography.

**Results:** Of the 100 eyes of 50 cases, suspicious ONH changes were found in 45 eyes of 24 glaucoma suspects, suspicious VFDs in 25 eyes of 18 glaucoma suspects and IOP > 21 mm of Hg/suspicious diurnal variation test &/or suspicious provocative test in 30 eyes of 20 glaucoma suspects. Of the 45 eyes of 24 glaucoma suspects with ONH changes, bilateral ONH changes were seen in 21 cases; rest 3 cases had unilateral ONH changes. Pallor of NRR and diffuse thinning of NRR was found in 44.4%, splinter hemorrhage in 11.1 %, notching of NRR in 11.1% and vertically oval cup in 33.3%. Regarding correlation of asymmetry of C/D with VFDs in glaucoma suspects, of the 50 glaucoma suspects, asymmetry of C/D was found in 19 persons, of which asymmetry of 0.1 -0.3 in 12 persons and >0.3 were found in 7 persons. Of the 19 glaucoma suspects with asymmetric C/D, VFDs were seen in 20 eyes of 14 persons (6 persons had bilateral VFDs, 8 persons had unilateral VFDs). VFD percentage of 83.3% was noted in C/D asymmetry between 0.1-0.3 and 142.9% when asymmetry was >0.3. So increasing asymmetry of C/D was related to increasing percentage of VFDs.

**Conclusion:** The nature of VFDs correlated with ONH changes in established POAG. Localized field defects were seen in early and moderate ONH changes and more generalized field defects were revealed in advanced ONH changes. The nature of VFDs revealed the typical arrangement of nerve fibers in the retina and the optic nerve and the typical pattern of glaucomatous nerve damage. Regarding correlation of C/D with IOP in established POAG, an increase of C/D with increase in IOP was observed.

**Keywords:** Primary open angle glaucoma, ocular hypertension, glaucoma suspect, optic disc changes, visual field changes.

## Introduction

Primary open angle glaucoma suspect and related entities are included in ICD #10 H40.<sup>1</sup>The American Academy of Ophthalmology; Preferred Practice Patterns Glaucoma Panel used the term glaucoma suspect to mean primary open angle glaucoma suspect.<sup>2</sup> Glaucoma of all types constitutes the second most common cause of legal blindness. POAG is the major health problem. It is important to identify the risk factors and monitor the glaucoma suspects earlier and in an accurate way so that the glaucoma related blindness can be prevented by intervention at the earliest sign of glaucomatous damage.<sup>3</sup>

The manifestations of glaucoma range from mechanical angle closure of outflow structures in patients with angle closure glaucoma (ACG), who typically present with ocular pain and acute visual loss, to increased resistance of outflow in patients with open angle glaucoma (OAG), who are often asymptomatic. Although glaucoma embodies a diverse group of diseases, all these diseases share common characteristics, the hallmarks of which include progressive irreversible damage to the optic nerve head and the retinal ganglion cells with corresponding visual field loss.<sup>3, 4</sup> Ocular hypertension (OHT) is defined as IOP >22 mmHg (2 standard deviations above the mean), but without any other abnormal features in the optic discs, VFs, or RNFL.<sup>5</sup>

## Aims and Objectives

- 1) To identify a group of POAG suspects from the patients attending the O.P.D and to monitor them periodically for a period of one year for detecting early signs of glaucomatous damage of ONH and glaucomatous VFDs.
- 2) To find out the percentage of different ONH changes in POAG suspects.
- 3) To find out the percentage of various VFDs in the POAG suspects.
- 4) To find out the relation among various ONH changes, IOP and VFDs in established POAG detected from the POAG suspects.

## Materials & Methods

The present study was carried out in Mala Gujri Memorial Medical College, Department of Ophthalmology, Kishanganj from July 15<sup>th</sup>, 2016 to June 14<sup>th</sup>, 2017. About 50 glaucoma suspects were selected for the study from the patients attending the O.P.D. The selection was made on the basis of findings of gonioscopy, applanation tonometry, direct ophthalmoscopy, slit lamp biomicroscopy, stereoscopic visualization of ONH by +90D lens, automated perimetry by Humphrey Field analyzer (central 30-2 test) and fundus photography.

## Selection Criteria

The presences of one or more of the following criteria were used for selection of glaucoma suspects<sup>6</sup>:

1. a) Intraocular pressure (IOP) more than 21 mm of Hg on more than one occasion. (b) diurnal fluctuation of IOP >5 mm of Hg and I or provocative test showing fluctuations of IOP >5 mm of Hg. c) asymmetry of the IOP between the two eyes of 5 mm of Hg or more by diurnal variation test and /or provocative test.
2. Suspicious optic disc changes<sup>7</sup>: (a) Cup: disc ratio>0.5, especially in vertical axis b) Asymmetry of disc cup>0.2 C/D c) Disc hemorrhage (superficial splinter hemorrhage) (d) Diffuse or focal notching of the disc rim, especially at the inferior and superior poles e) Vertically oval cup (f) Pallor neuroretinal rim (NRR) (g) Thinning of NRR.
  - (a) Suspicious visual field<sup>7</sup>: (a) generalized depression. (b) baring of blind spots d) Nasal step < 10° (d) relative scotoma<5°
  - (b) Presence of one or more of the associated risk factors in persons having ONH changes and /or VFDs and/or IOP>21 mm of Hg such as strong family history of glaucoma, age above 40 years, myopia, systemic hypertension, diabetes mellitus, cardiovascular diseases, migraine, and peripheral vasospasm.

In this study, the term glaucoma suspect is used to

mean primary open angle glaucoma suspect. Gonioscopy was done to select the cases with open angle.

#### Exclusion Criteria

- 1) Angle closure glaucoma
- 2) Secondary open angle glaucoma
- 3) Non-cooperative patients
- 4) Patients on any drug or operative procedure that can affect IOP
- 5) Those who were attending hospital irregularly.

The study group was followed up every 3 monthly intervals for a period of one year and on each follow up, gonioscopy, applanation tonometry, direct ophthalmoscopy, slit lamp biomicroscopy, stereoscopic examination of ONH by +90D lens and automated perimetry were done. Any progression of ONH changes, and/or VFDs and /or alteration of IOP were noted. Fundus photography was done if definite progression of ONH changes were found. Data were analyzed using standard statistical procedures.

#### Results

Of the 100 eyes of 50 cases, suspicious ONH changes were found in 45 eyes of 24 glaucoma suspects, suspicious VFDs in 25 eyes of 18 glaucoma suspects and IOP > 21 mm of Hg/suspicious diurnal variation test &/or suspicious provocative test in 30 eyes of 20 glaucoma suspects. Of the 45 eyes of 24 glaucoma suspects with ONH changes, bilateral ONH changes were seen in 21 cases; rest 3 cases had unilateral ONH changes. Pallor of NRR and diffuse thinning of NRR was found in 44.4%, splinter hemorrhage in 11.1 %, notching of NRR in 11.1% and vertically oval cup in 33.3%.

Regarding correlation of asymmetry of C/D with VFDs in glaucoma suspects, of the 50 glaucoma suspects, asymmetry of C/D was found in 19 persons, of which asymmetry of 0.1 -0.3 in 12 persons and >0.3 were found in 7 persons. Of the 19 glaucoma suspects with asymmetric C/D, VFDs were seen in 20 eyes of 14 persons (6 persons had bilateral VFDs, 8 persons had unilateral VFDs). VFD percentage of 83.3% was

noted in C/D asymmetry between 0.1-0.3 and 142.9% when asymmetry was >0.3. So increasing asymmetry of C/D was related to increasing percentage of VFDs.

Regarding relation of C/D with VFDs in glaucoma suspects, eyes with C/D 0.2 had no VFDs, there was gradual increase in VFDs with increasing C/D, VFDs were 100% when C/D 0.7 and above. Of the 100 eyes of glaucoma suspects, 25 eyes of 18 persons had VFDs. Seven persons had bilateral VFDs, and 11 persons had unilateral VFDs. Of the 25 eyes with VFDs, enlargement of blind spot was seen in 8%, paracentral, Seidel, arcuate and double arcuate scotomas in 40%, Roenne's central nasal step in 8%, localized or generalized field constriction in 40%. Defect could not be studied (atypical VFDs) in 4%. Of the 100 eyes of 50 glaucoma suspects, 28 eyes of 18 persons had IOP > 21 mm of Hg on more than one successive occasions. Of the 18 persons with raised IOP, 10 persons had IOP > 21 mm of Hg on both eyes and the rest 8 persons had raised IOP in one of the eyes.

Of the rest 72 eyes (of 32 persons of bilateral IOP < 21 mm of Hg and 8 persons of unilateral IOP < 21 mm of Hg), positive provocative test (Water Drinking Test) showing fluctuation > 5 mm of Hg and positive diurnal variation showing IOP fluctuation > 5 mm of Hg in one eye each of 2 different persons were found. About 9 eyes of 7 persons (2 persons with bilateral and 5 persons with unilateral involvement) with raised IOP/positive provocative test and /or diurnal variation and ONH changes, 3 eyes of 2 persons (1 person with bilateral involvement and 1 person with unilateral involvement) with raised IOP/positive provocative test and /or diurnal variation associated with VFDs and 8 eyes of 4 persons (bilateral involvement) with raised IOP/positive provocative test and diurnal variation only (no associated ONH changes and/or VFDs) were found. About 10 eyes of 8 persons (2 persons with bilateral involvement and 6 persons with unilateral involvement) with raised IOP > 21 mm of Hg/positive provocative test and/or diurnal variation with ONH changes and VFDs were

found. These glaucoma suspects were established as POAG.

Regarding percentage of eyes with raised IOP/positive provocative test and/or diurnal variation and correlation with ONH and VFDs, raised IOP with ONH changes was found in 30%, raised IOP with VFDs in 10%, raised IOP only in 26.7% and raised IOP, ONH changes and VFDs in 33.3% eyes. Regarding risk factors, of the 50 glaucoma suspects, risk factors were present in 43 persons. Multiple risk factors were also present in the same person in 45%. Age > 40 years was present in 23%, family history of POAG in 25%, myopia > 1D in 20%, diabetes mellitus in 15% and systemic hypertension in 5%. No glaucoma suspect was found with migraine, cardiovascular diseases and peripheral vasospasm hence no association could be established.

Of the 45% glaucoma suspects with multiple risk factors, age >40 years and family history of POAG was 23%, age >40 years and family history of POAG and myopia >1D was 10%, diabetes mellitus with family history of POAG was 2% and age >40 years with diabetes mellitus with family history of POAG was 10%. Of the 50 selected glaucoma suspects, POAG was established in only 8 persons during the follow-up period. All the 8 established cases of POAG had multiple risk factors.

Of the 8 established cases of POAG (total 10 eyes), laminar dot sign with saucerization was found in 20%, bayoneting of disc edge with saucerization in 30%, pallor of NRR, thinning of NRR, notching of NRR & peripapillary chorioretinal atrophy with laminar dot sign with baring of circumlinear vessels with bayoneting at disc edge in 40% and nasal shifting of vessels with laminar dot sign with saucerization in 1%.

In each of the established case of POAG, typical glaucomatous VFDs were present; so, the association between ONH changes in POAG and VFDs was 100%. Regarding correlation of C/D with IOP in established POAG, the following observations were made: eyes with IOP ranging 21-30 mm of Hg had mean C/D 0.55, eyes with IOP ranging 31-40 mm of Hg had mean C/D 0.75.

When IOP was above 41 mm of Hg. mean C/D was 0.9. So, there was an increase of C/D with increase in IOP.

## Discussion

### Margin in Glaucoma Suspects

According to Drance et al<sup>8</sup>, splinter hemorrhages, usually near the margin of the optic nerve head, mostly in the inferior quadrant, are a common feature of early glaucomatous damage. In the present study splinter hemorrhage at the disc margin was found in 11.1 % cases.

### CUP-Disc Asymmetry And Correlation with VFD in Glaucoma Suspects

Annaly MF (1967)<sup>9</sup> showed that the physiological cup tends to be symmetrical between the two eyes of the same individual and a C/D of more than 0.2 between the two eyes of the same individual occurred only in 1% of the populations. In the present study, out of the 50 glaucoma suspects, asymmetry of C/D was found in 19 persons, of which asymmetry of 0.1 -0.3 in 12 persons and >0.3 were found in 7 persons. Of the 19 glaucoma suspects with asymmetric C/D, VFDs were seen in 20 eyes of 14 persons (6 persons had bilateral VFDs, 8 persons had unilateral VFDs). VFD percentage of 83.3% was noted in C/D asymmetry between 0.1-0.3 and 142.9% when asymmetry was >0.3.

### C/D & VFDs in Glaucoma Suspects & Established POAG

According to Shields<sup>1</sup>, when the discs in normal population was studied by direct ophthalmoscopy, the distribution was found to be non-Gaussian with most eyes a C/D of 0.0- 0.3 and only 1-2% being 0.7 or greater, when stereoscopic views were utilized, a Gaussian distribution was found with a mean C/D of 0.4 and approximately 5% had C/D of 0.7. Yablonski ME et al<sup>10</sup> (1960) showed that an increase in C/D is an important predictor of glaucomatous VFDs. Gloster pointed out the relationship between the vertical C/D and the percentage of VFDs.<sup>11</sup> There was an increase in the prevalence of VFOs increased with C/D and was significantly increased when the vertical C/D was over 0.7. Armaly<sup>9</sup> (1967) and Drance et al<sup>12</sup>

(1978) reported that increased C/D is an important predictor of glaucomatous VFDs. The present study with 100 eyes of 50 glaucoma suspects found that eyes with C/D 0.2 had no VFDs. There was gradual increase in VFDs with increasing C/D. VFDs were 100% when C/D 0.7 and above. The present study detected 10 eyes of 8 established case of POAG which had mean vertical C/D ranging from 0.55-0.9. VFDs were present in 100 %. Thus, the present study corroborates with the results of previous studies.

#### **Visual Field Changes in Glaucoma Suspects**

In the present study with 100 eyes of 50 glaucoma suspects, 25 eyes of 18 persons had VFDs. Seven persons had bilateral VFOs, 11 persons had unilateral VFDs. Enlargement of blind spot was seen in 8%, paracentral, Seidel, arcuate and double arcuate scotomas in 40%, Roenne's central nasal step in 8%, localized or generalized field defect in 40%. Defect could not be studied (atypical defects) in 4%. In the present study, we have used Humphrey Automated Field Analyzer to detect the changes in the field of vision of the glaucoma suspects. Central 30-2 Threshold Test was utilized with SITA-standard strategy. Quigley HA, Sommer A (1995) in a comparative study of VFDs in glaucoma using manual Goldmann Perimetry and Automated Static Perimetry concluded that Automated Static Perimetry detects VFDs earlier than manual Goldmann Perimetry.<sup>13</sup>

#### **Correlation between ONHs and VFOs in established POAG:**

The present study detected 8 established cases of POAG where typical glaucomatous ONH changes were present with typical VFDs. So the association of ONH changes with VFDs in established POAG was found to be 100%. Study of relevant literature reveals that in most patients with glaucoma, clinically recognizable ONH changes precede VFDs and the presence or absence of glaucomatous VFDs can usually but not always, be predicted from the appearance of the ONH.<sup>5</sup>

Quigley et al (1982)<sup>14</sup> attempted to correlate axon loss in the ONH with the VFDs. Although limited by small sample size their works did suggest that-

not only does nerve fiber loss occur prior to reproducible field defect in some patients with elevated IOP, but the extent of axonal loss may be much more than the corresponding field change. In addition to the fact that presence of ONH cupping predicts the presence of VFDs, the nature of ONH cupping can be used to predict the type of VFDs. Extensive or focal loss of neural tissue, especially in the superior or inferior poles is the most reliable indicator of VFDs and is usually associated with a field defect in the corresponding arcuate area. In some cases, field loss occurred before the pallor reaches the disc margin.<sup>5</sup>

Garway-Heath DF, Poinosawmy D, Fitzke FW, Hitchings RA (2000)<sup>15</sup> showed that a clinically useful map that relates visual field test points to regions of the ONH has been produced. The map will aid clinical evaluation of glaucoma patients and suspects, as well as form the basis for investigations of the relationship between retinal light sensitivity and ONH structure. The studies of Schuman J, Hee MR, Puliafito D et al<sup>16</sup> using advanced techniques like Optical coherence Tomography (OCT) showed high degree of correlation of nerve fiber layer thickness with VFDs detected by Humphrey Automated Field Analyzer.

The present study with 100 eyes of 50 glaucoma suspects revealed 8 established cases of POAG in which ONH changes can be correlated with the VFDs and thus establishes the fact that VFDs in glaucoma correlate with the damage to the neurons in retina with reflection of their characteristic arrangement within the retina and within the optic nerve. These findings were documented by showing the VFDs by automated static perimetry and corresponding ONH changes were shown by fundus photograph of the same case. Thus, results of the present study corroborate with previous studies.

#### **Correction between IOP and Optic Disc Changes in Glaucoma Suspects**

In the present study, 28 eyes of 18 persons with IOP>21mm of Hg and one eye each of positive provocative test and diurnal variation of 2 different persons were found. Nine eyes (of 7 persons) with

raised IOP (including positive provocative test and/or diurnal variation) associated with ONH changes, 3 eyes (of 2 persons) with raised IOP (including positive provocative test and/or diurnal variation) associated with VFDs and 8 eyes (of 4 persons) with raised IOP/ positive provocative test and/or diurnal variation only were found. Ten eyes of 8 persons (2 persons with bilateral and 6 persons with unilateral manifestations) had raised IOP/ positive provocative test and/or diurnal variation, ONH changes and VFDs. These were established POAG. Tanito M, et al<sup>17</sup> in their study "Correlation between intraocular pressure level and optic disc changes in high-tension glaucoma suspects" concluded that the IOP level correlates with topographic changes in the optic disc in eyes of patients suspected of having high-tension glaucoma.

#### **Correlation between IOP and Optic Disc Changes in Established POAG**

In the present study, 10 eyes of 8 established cases of POAG showed increase in vertical mean C/D with increase in IOP. Pohjanpelto PE et al (1974) revealed in his study with 307 patients, the prevalence of ONH damage each pressure group.<sup>18</sup> He concluded that with increasing IOP, there was increased incidence of nerve fiber damage there by leading to VFDs. Thus, the present study corroborates with the results of previous studies.

#### **Importance of Risk Factors in Glaucoma Suspects**

Glaucoma suspect may have one or more ocular and /or systemic risk factors that may lead to the development of POAG.<sup>6</sup> The strong risk factors include increasing age<sup>18</sup>, strong family history<sup>6</sup>, African American descent<sup>19</sup>, elevated IOP, thinner central corneal thickness (in Ocular Hypertension Treatment study, the cut off mark was taken to be 556µm but it varies in different population<sup>20</sup>), larger than average pattern standard deviation index on otherwise normal, baseline threshold visual field examinations (> 1.98 dB,30-2 test, Humphrey perimeter).<sup>20</sup> Systemic hypertension, Cardiovascular disease, myopia, migraine and peripheral vasospasm have been implicated as

possible risk factors in the development of glaucomatous optic nerve damage.<sup>21,22,23</sup>

In the present study, of the 50 glaucoma suspects, risk factors were present in 43 persons. Multiple risk factors were also present in the same person in 45%. Age > 40 years was present in 23%, family history of POAG in 25%, myopia > 1D in 20%, diabetes mellitus in 15% and systemic hypertension in 5%. No glaucoma suspect was found with migraine, cardiovascular diseases and peripheral vasospasm hence no association could be established. Gordon MO, et al<sup>20</sup> in their study concluded that increasing age is a definite risk factor for POAG. Bankes JL (1968) in his study of 3000 individuals from general population found that the prevalence of POAG increases with age.<sup>24</sup> Several studies revealed strong family history of POAG is a definite risk factor. POAG is said to have a genetic basis and the inheritance is likely to be polygenic and multifactorial. The Baltimore Eye Survey<sup>25</sup> found that the relative risk of having glaucoma is increased 3.7-fold for individuals who have siblings with POAG. Family history of glaucoma in a sibling is the greatest risk factor, followed by glaucoma in a parent. Myopia is another risk factor.<sup>22</sup> The prevalence of POAG is more among the myopics as well as an increased frequency of myopia is seen among those who have POAG, ocular hypertension and normal tension glaucoma.<sup>5</sup> A systemic review and meta-analysis published online in 2014 concluded increased risk of POAG in individuals with diabetes mellitus.<sup>26</sup>

#### **Conclusion**

The following conclusion can be drawn from the present study:

The commonest presenting feature of glaucoma suspect is ONH changes, followed by raised IOP and VFDs. There was an increase in the percentage of VFDs with increase in asymmetry in the C/D between the two eyes. There was a gradual increase in the percentage of VFDs with increasing C/D, and when the ratio was 0.7 or more, all the eyes had VFDs. The nature of VFDs revealed localized as well as generalized defects.

The maximum percentage of VFDs were localized defects like paracentral scotoma, Siedel, arcuate and double arcuate scotomas, equalized by localized or generalized field constriction (40% each) and followed by nonspecific changes like enlargement of blind spot. There is a significant role of risk factors in glaucoma suspects. In those glaucoma suspects who had multiple risk factors, POAG was confirmed. Thus, we can come to the conclusion that the presence of one or more of the risk factors in glaucoma suspects increases the vulnerability of glaucomatous optic nerve damage.

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