Mid-peripheral visual field defects in glaucoma

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Abstract
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MID-PERIPHERAL VISUAL FIELD DEFECTS IN GLAUCOMA

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A thesis submitted to the faculty of the
College of Optometry
Pacific University
Forest Grove, Oregon
for the degree of
Doctor of Optometry
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Advisor:
Leland Carr, O.D.
PERIPHERAL VISUAL FIELD DEFECTS IN GLAUCOMA

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ABSTRACT

A Humphrey automated perimeter was used to measure the peripheral 30 to 60 degrees of vision with mid-peripheral field static threshold targets in 41 recently diagnosed glaucoma or "glaucoma suspect" eyes and 16 eyes of normal controls. The overall mean defect of the 30-60 degree visual field increased 5.11 decibels in the glaucomatous population when compared to the controls. The individual quadrants of the mid-peripheral field of each glaucoma subject were analyzed and quantitatively compared to the corresponding quadrant mean defect of the controls. The mean defect of the superior and the inferior field of the glaucoma subjects significantly differed from the overall mean defect of the controls. Differences on comparison of quantitative defects in the nasal periphery was less significant. This study suggests that peripheral field testing provides useful information in the detection of glaucoma. It also suggests that the analysis of the overall mean defect offers statistically relevant data upon which to judge whether field defects are pathological or normal.

INTRODUCTION

Within the optometric community today it is generally accepted that the presence of elevated intraocular pressure in isolation is insufficient for proper and final diagnosis of glaucoma. Rather, diagnosis of glaucoma must also include
demonstration of compromised retinal ganglion cell axons manifested as nerve fiber layer defects with accompanying evidence of optic disc pathology. It is in conjunction with this process that perimetric evidence of glaucomatous visual field defects will then follow. According to the American Optometric Association Clinical Guidelines and the American Academy of Ophthalmology Preferred Practice Patterns, automated perimetry is the best method currently available for studying visual field defects in glaucoma.

It has been shown that when nerve fibers are initially damaged in glaucoma, paracentral scotomas are amongst the first visible signs of visual field loss. Similarly, central nasal steps and temporal sector-shaped defects have been well documented and generally understood to be early and characteristic signs of glaucoma. Perhaps it is to this knowledge that little research has concentrated on the possibility of visual field loss in the periphery occurring early in the glaucomatous process.

Recently, with the advent of more sophisticated perimetric techniques, it has been shown that although the central 30 degrees often provides the earliest information, the first detectable field defects in glaucoma may occasionally be found outside this central zone. Spaeth found that 12% of his glaucoma patients exhibiting increased intraocular pressure and
progressive nerve fiber layer damage had peripheral rather than central field loss.

Further, recent research has concentrated on the significance of overall field decibel level depression as being an early glaucomatous sign despite the lack of obvious visual field scotomas.\textsuperscript{8,9,10} It has been shown that decibel differences greater than 1.4 between a subject's left and right eye should occur in less than 1\% of the population.\textsuperscript{8} Indeed, it has also been demonstrated that the progression of glaucomatous field defects will typically first occur as a subtle threshold decibel level depression (deepening) prior to obvious field defect expansion.\textsuperscript{11}

It is the authors' intention to evaluate the mean of the field defect, in decibels, for glaucoma patients and compare these findings to a group of set controls. Further, we intend to examine the new and growing opinion that glaucomatous visual field defects occur in the periphery prior to, or in conjunction with, the appearance of definitive central scotomas.

METHODS

Data was collected from 41 eyes of 21 early glaucoma patients. There were 13 males and 8 females between the ages of 37 and 74 (mean 52.1 years). Patients evaluated in the Pacific University Glaucoma Service or the Ocular Disease and Special
Testing Clinic were selected for this study. All subjects had previously documented central, threshold-related visual field tests performed by the Humphrey Field Analyzer. Thus, these subjects were considered experienced with Humphrey automated perimetry.

Criteria used in the selection process of these subjects included any one of the following to qualify them as an early glaucoma suspect:

1. IOP (Intraocular pressure) readings obtained by applanation tonometry were consistently above 22 mm of Hg in at least one eye.
2. Diurnal pressure variations were greater than or equal to 5 mm of Hg in at least one eye.
3. Cup/disc ratio of the optic nerve head was greater than or equal to .5/.5 (horizontal/vertical dimension) in at least one eye.
4. A difference of .2mm between the two cup/disc ratios in each eye was present.
5. An already existing visual field defect in the central 30 degrees was previously obtained using threshold-related perimeter testing.
6. Pallor of the optic disc was present leading to the suspicion of glaucoma.
7. Glaucomatous cupping and/or undercupping of the optic disc was present.
8. Significant risk factors could be documented, leading to the suspicion of glaucoma were present (including familial history of glaucoma and high myopia or hyperopia both greater than six diopters).

Non glaucomatous patients, with no history of ocular disease, represented the control group. This included 8 different patients, 6 females and 2 males, who represented 16 different eyes. Ages ranged between 25 and 30 years (mean 26.4 years).

Both groups underwent peripheral Humphrey perimeter testing. The 60-2 threshold-related test was used to evaluate 68 points in the peripheral 30 to 60 degrees. This field test contains a grid spacing of 12 degrees, that either examines along the horizontal and vertical midlines or is offset symmetrically from these reference lines. A standard, white, Goldmann size III spot target, subtending a 0.43 degree diameter, was employed in the testing of all points for a duration of 0.2 seconds. Background illumination for the Humphrey Field Analyzer was 31.5 apostilbs (asb.) and room illumination was low ambient light.12

All data analyzed for this study met Humphrey's patient reliability criteria concerning fixation losses, false positive and false negative errors, and fluctuation. This meant that each eye tested had to present with a fixation loss value of less than 20 percent of the total questions asked. A value higher than this
percentage may indicate that the subject was fixating poorly or that the blind spot was misplotted. Values for false positive and false negative errors that were less than 20 to 30 percent of the total questions asked were also required in determining subject reliability. This was used to help eliminate either "trigger happy" subjects with high false positive errors or inattentive and possibly fatigued subjects who had high false negative errors. Although no fluctuation value criteria was set prior to testing subjects, a fluctuation value was measured for each subject. A fluctuation value, which the Field Analyzer measures throughout the test, reflects the consistency of the patient's answers during the test by testing twice at ten preselected points. The lower the fluctuation value, the more consistent in answering a patient is considered to be. A high fluctuation value, found across the field may indicate either an inattentive patient or that the patient does not understand the test.

For all eyes tested each of the 68 points was evaluated individually to determine whether a defect was present. A threshold value of less than 5 decibels (db) from the expected threshold value for each point, as determined by individual performance by the Humphrey Field Analyzer, was considered to be a defect. Any established defect was then assigned a defect depth value, in decibels, by the Humphrey Field Analyzer. The defect depth value was then used in the interpretation of the obtained data.
Pausing was encouraged and permitted at any time throughout the test, and this resulted in 28 of the 29 total subjects completing testing for both eyes during one visit. This was done in an attempt to decrease patient fatigue and at the same time increase patient reliability. Because each subject volunteered to participate, all subjects were considered to have a positive behavior towards testing.

RESULTS

To analyze our results the Wilcoxon Signed-Ranked test was employed as our statistical methodology. This statistical test was chosen for its nonparametric version of the two group paired t-test.

The mean defect of each field sector, as shown in Table 1, was calculated for each group, and the values were then incorporated into the Wilcoxon test. Superior and inferior visual field sectors were analyzed within each group. Mean superior defects were not significantly different from mean inferior defects within either the glaucoma group or the control group (figure 1). Figure 2 shows the overall mean defect of the glaucoma subjects versus the overall mean defect of the control subjects to differ by 5.33 dbs. The Wilcoxon test reveals these differences to be statistically significant. Comparison of individual sectors of the visual field shows that the mean defect of the inferior field for individual glaucoma subjects differed
significantly from the mean defect of the *inferior field* for the controls (figure 1). Further, the mean defect of the *superior field* is greater for individual glaucoma subjects as compared to the mean defect of the *superior field* of the control group. The mean defect of the superior field is statistically significant, although to a lesser degree than the mean defect of the inferior field (figure 1). The mean defect of the *nasal field* of the glaucoma group as compared to the mean defect of the *nasal field* of the control group was not statistically significant.

The mean defect of each glaucoma subject was determined and compared to the overall mean defect of the control group. Figure 3 illustrates that 17 of the 21 glaucoma subjects had a mean defect of 2.08 dbs larger than the overall mean defect of the control group.

**DISCUSSION**

The nature of perimetry is such that the interpretation of visual field defects is often difficult. Indeed, perimetry is a subjective measurement relying on the attentiveness and cooperation of the patient, as well as on the patient's familiarity and understanding with the testing process.13

While "classic" glaucomatous visual field changes have been described in numerous texts and journals, clinically, visual field results often fail to be so "clear cut". The findings of
Drance et al.\textsuperscript{15} that increased intraocular pressure may affect the general visual field pattern diffusely, implies the importance of analyzing overall field defect depression. Indeed, localized cluster defects have been known to vary greatly within the same patients depending on different testing times.\textsuperscript{16} Further, it has recently been shown that changes in threshold sensitivity exceeding 6 dbs should occur in fewer than 1 percent of field test locations and that overall mean sensitivity greater than 1.4 dbs should occur in fewer than 1 percent of normals.\textsuperscript{8}

In this study, a different approach was employed in that overall mean defects of glaucomatous patients were compared to an overall mean defect of normals. The findings suggest that the overall mean defect of glaucoma subjects is significantly higher than that of normals in the peripheral visual field. Two important concepts are inferable based on these findings. First, we may deduce that it is valid to compare the measured mean defects in an eye with suspected disease with those of a normal eye. Second, that significant peripheral perimetric defects may occur, despite the lack of obvious central scotomas, and these defects may manifest earlier in the disease course than previously thought.

However, as age-matching was not a criteria for this study, one may suggest that the influence of age may explain the difference in the mean defect between the two groups. However, it is important to state that each eye's mean defect is,
in fact, a numeric expression of the deviation from the expected age-corrected norm as determined by the Humphrey Field Analyzer. Thus, in determining the overall mean defect for each subject, age-corrected norms were utilized. It is also important to note that a defect depth printout enables the interpreter to analyze the exact depth as well as the number of contributing defect points. Because each point's defect is determined by comparing the threshold level of surrounding points and the mirror image points in other quadrants, employing an overall mean defect analysis is a clinically relevant adjunct to a point-by-point analysis of defects.

In 81 percent of glaucoma subjects the overall mean defect was shown to be significantly higher than the overall mean defect of the controls. Accordingly, the mean defect of the superior and inferior visual fields in the glaucoma group were statistically higher than that of the control group. Surprisingly, the overall mean defect for the nasal visual field of the glaucomatous group did not differ significantly from that of the controls. This is contrary to the findings of Caprioli and Spaeth\(^6\) who found 37% of eyes of their glaucomatous group had peripheral nasal steps. Further, we found no statistical difference within the normal or glaucoma group when comparing the superior field defects to the inferior field defects.
CONCLUSION

This study suggests that interpretation of the peripheral visual field provides relevant information regarding early glaucomatous field changes. Peripheral visual field testing may at the very least assist in deciding when more in-depth visual field testing is required. It may be that an analysis of mean defects offers insight into glaucomatous field changes and should be emphasized more when looking for signs of retinal compromise in early glaucoma.

It would be of interest to follow changes in the mean mid-peripheral defect as the disease process progresses. As has been shown, early paracentral scotomas and steps are not always consistent between testing dates amongst glaucoma patients. Comparing changes in the overall mean defect for the more peripheral field might allow more reproducible interpretation of the progression of the glaucomatous condition.
REFERENCES


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Fig. 1 Distribution of the mean defect (in Decibels) for the glaucomatous subjects as compared to the control subjects.
Fig. 2. Distribution of the Superior mean defect as compared to the Inferior mean defect within the glaucomatous group and control group, respectively.
Fig. 3. Mean mid-peripheral defect of individual glaucoma subjects as compared to the mean defect of the control group.