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COMPARISION OF VISUAL FIELD DEFECTS IN PRIMARY OPEN ANGLE GLAUCOMA WITH FREQUENCY DOUBLING PERIMETRY(FDP) VERSUS STANDARD AUTOMATED PERIMETRY(SAP)

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ABSTRACT

Objectives: To compare the efficacy of FDP to detect early visual field defects changes as compared to SAP in POAG patients. **Method**: Non randomized, cross-sectional study included 70 diagnosed patients of POAG and 70 healthy controls of different age groups and of either sex attending the glaucoma clinic of ophthalmology department. Patients with best corrected visual acuity > 20/30, refractive error < ±6 dioptres sphere and < ± 2 dioptres cylinder and with baseline IOP ≥ 21mm of Hg in diurnal curve were included, while patients with history of any previous ocular surgery, significant central lens opacities, retinal disease producing visual field defects, ocular hypertension, normal tension glaucoma, primary angle closure glaucoma, were excluded from the study. Participants underwent examination with Standard Automated Perimetry (SAP) with Humphrey Visual Field Analyzer using 30-2 SITA Standard and Frequency Doubling Technology Perimetry (FDT) with Humphrey Matrix using 30-2 full threshold using ZEST strategy. **Result:** In our study we found FDP is a quick procedure (Mean test duration was significantly shorter with FDT Matrix as compared to SAP SITA (326.70 ± 17.70 vs. 380.50 ± 72.00 seconds, respectively; P<0.001) and detect early visual field defects. But FDT does not detect larger defects as compared with SAP SITA. The defects detected by FDT Matrix are smaller and deeper i.e., detected by greater light intensity than SAP SITA. Also there was no significant correlation found between the sensitivity measured by the two methods in the various quadrants. **Conclusion:** FDT's major contribution may be as a complement to SAP for detecting visual field loss but not as a replacement of SAP.

KEYWORDS: Frequency doubling perimetry; Standard automated perimetry; Primary open angle glaucoma.

Abbreviations

FDP- Frequency doubling perimetry
SAP- Standard automated perimetry
POAG- Primary open angle glaucoma
RGC- Retinal ganglion cells
SITA- Swedish Interactive Threshold Algorithm

INTRODUCTION

Glaucoma is one of the major causes of irreversible blindness in the world responsible for 12% of all blindness.[1] It is a progressive disease in which retinal ganglion cells (RGC) death is associated with visual impairment.[2] There are three cardinal features of glaucoma – raised intraocular pressure (IOP), optic nerve head changes and visual field defects. The purpose of visual field assessment in glaucoma is to detect early field defects, determination of specific patterns of visual field loss for differential diagnostic purposes, and monitoring of patients for evidence of progression or stability of visual field loss.[3]

Visual field assessment stands as a major pillar both in the diagnosis and in the follow-up of glaucoma patients. Standard methods of visual field examination suffer many shortcomings including the cumbersome and time-consuming nature of tests, the delay in detection of defects, and the difficulty in assessing progression. Investigators have focused on developing new tests that can evaluate various functional aspects of retinal ganglion cells, as well as on upgrading algorithms to shorten test times.[4]

The retinal ganglion cells of different sizes have distinct physiological functions. Small cells that project to the parvocellular layers of the lateral geniculate body belong to the "P-cell pathway" which conveys information on color, high spatial frequency, and pattern discrimination,while large cells that project to the magnocellular layer belong to the "M-cell pathway" dealing with motion detection, low spatial frequency, and high temporal frequency.

There are two subtypes of M-cell. One is the Mx-cell, which has linear characteristic summation in receptive fields and another is the My-cell that has a non-linear character. Testing of the My pathway appears to be a strong candidate for an effective screening procedure for glaucoma, because My-cells have a larger nerve fiber diameter and fewer redundancies than Mx cells. The My-cell represents only 3%–5% of the total number of ganglion cells, indicating that the loss of even a single cell will lead to a distinct scotoma in the lattice of My-cell receptive fields.[5-7]

Maddess proposed that a subclass of the magnocellular ganglion cells (namely My cells) responds to the low spatial frequency and high temporal frequency features of the FDT stimulus.[8] FDT perimetry might therefore be able to detect glaucomatous damage sooner than SAP, by targeting this subpopulation of large ganglion cells which are affected early by glaucoma and which are less numerous than other ganglion cells.[9-10] Secondly, the My cells have a lower coverage factor, with around three of them seeing each point in visual space, compared to around 15 paravocellular Py cells. Consequently, if one cell in either array is lost, the My defect will be easier to detect.

The frequency-doubling effect is a phenomenon that occurs when a low spatial-frequency (<4 cyc/deg) grating that undergoes high temporal-frequency (>15 Hz) counterphase flicker appears as a shimmering grating pattern with double the original spatial frequency. The basis of frequency doubling is thought to reside in a subset of M-cells, called My-cells, which account for only 15% to 25% of the M-cell population, or 3% to 5% of the total ganglion cell population.[11-12]

Standard methods of visual field examination suffer many shortcomings including the cumbersome and time-consuming nature of tests, the delay in detection of defects, and the difficulty in assessing progression. To overcome these problems new tests were adopted like frequency doubling technology perimetry which was first described by Kelly[13-14] in 1966, that acts as a useful glaucoma screening modality by virtue of the significantly reduced testing time, when compared with standard automated perimetry (SAP).

Advantages of FDT perimetry over SAP includes

1. FDT perimeter is compact in size and portable
2. Low variability and strong validity
3. Requires less time to perform and less technically challenging
4. No patching of the other eye is required, making this machine less claustrophobic and thus very patient friendly
5. High sensitivity and specificity
6. Ability to detect visual field damage and progression earlier than SAP
7. Test–retest variability with FDT does not increase with defect severity or eccentricity as much as it does with SAP, probably because of the large stimulus size used.[15-16]

Method: Non randomized, cross-sectional study included 70 diagnosed patients of POAG and 70 healthy controls in the glaucoma clinic of ophthalmology department. The approval for the above said study was sought from ethical committee of hospital and an informed consent was obtained from the patients for the above said study.

All participants underwent following investigations:

1) Complete ophthalmological examination involving best corrected visual acuity
2) Intraocular pressure was measured using Applanation Tonometer (AT) and Biomicroscopy of anterior segment with slit lamp biomicroscopy (Haag-Streit 900 slit lamp Haag-Streit AG, Koeniz, Switzerland)
3) Corneal pachymetry
4) Gonioscopy was done with single mirror goniolens.
5) Dilated (phenylephrine 2.5% and tropicamide 1%) fundus examination done with

a. Slit lamp biomicroscopy with +90D lens to evaluate the optic nerve head.
b. Fundus camera was used to document optic nerve head.

6) Quantitative analysis of the nerve fibre layer with Spectral Domain Cirrus Zeiss HD OCT.
7) All Participants were examined using STANDARD AUTOMATED PERIMETRY (SAP) with Humphrey Visual Field Analyzer (Carl Zeiss Meditec, Dublin, CA), using 30-2 SITA Standard and FREQUENCY DOUBLING TECHNOLOGY PERIMETRY (FDT) with Humphrey Matrix (Carl Zeiss Meditec) using 30-2 full threshold using ZEST strategy for a period of 9 months.

In most eyes, SAP and FDT were performed randomly on the same day under ambient light conditions with a gap of at least 15-20 minutes given to reduce fatigue related errors. All the subjects were made to wear appropriate refractive corrections for both the tests and the pupils had a diameter of at least 3 mm. Only the reliable (fixation losses<20%, false-positives and false-negatives <33%) visual fields were included in the study. In case of unreliable fields, the test was repeated after few days. If both eyes were eligible for the study, the eye with more reliable field was selected for analytical purposes.

For comparative analysis, the blind spot thresholds were not used. The two locations above and below the blind spot and edge points (H-P-A criteria)were excluded, leaving 52 points for analysis in the SAP as well as in FDT Matrix.

Visual fields were considered to be abnormal according to H-P-A criteria:

1. A cluster of 3 or more non edge points all of which are depressed on the pattern deviation plot at p<5% and one of which was at p<1%

(Edge points were taken to be valid in case of 24-2 program)

2. CPSD or PSD (in SITA) < 5%
3. Glaucoma hemifield test outside normal limits

A visual field defect had to be reproducible in 2 consecutive fields for it to be considered as a visual field defect.

DEFECT SIZE: The size of the glaucomatous defects was determined by counting the number of abnormal points in the pattern deviation plot as per Anderson's criteria No.1.

DEFECT DEPTH: The depth of the defect was assessed by averaging the threshold values of the abnormal points in the pattern deviation plot.

RESULTS

Of the 70 POAG cases studied, there were 42 (60%) males & 28 (40%) females and of 70 controls, 49 (70%) were males and 21 (30%) were females .The age of cases in our study ranged from 40-78 years with mean age of 60.70 years. SAP and FDT were performed randomly on the same day under ambient light conditions with a gap of at least 15-20 minutes given to reduce fatigue related error. Mean test duration was found significantly shorter with FDT Matrix as compared to SAP SITA (326.70 ± 17.70 vs. 380.50 ± 72.00 seconds, respectively; P<0.001) whereas there was no significant difference in the control group (319.22 ± 59.70 vs. 317.26 ± 17.98 seconds; p 0.811) shown in figure1.

The mean threshold in SAP SITA was found to be significantly higher as compared to FDT Matrix (p<0.001) with a strong correlation between the measurements in both the POAG and control group (r=0.872; p<0.001 and r=0.865; p<0.001 respectively) shown in figure2.

Mean Quadrantic Sensitivity Variation: The visual field included a total of 52 points and its analysis was made globally and by 4 quadrants: superior temporal - 13 points; inferior temporal - 13 points; superior nasal - 13 points; inferior nasal - 13 points. For each quadrant mean sensitivity was calculated on the basis of threshold values (Table 1 & 2).

Number of points depressed at level of p<1% was significantly higher in SAP SITA as compared to FDT Matrix in the glaucoma group whereas there was no significant difference at level of p<5%, p<2% and p<0.5%. In the control group, number of points depressed at level of p<5%, p<2% and p<1% was significantly higher in SAP SITA as compared to FDT Matrix whereas there was no significant difference at level p<0.5%.

Mean Defect Size: Mean defect size was the mean of all the number of abnormal points in the Pattern Deviation plot shown in figure3.

MEAN DEFECT DEPTH: Mean defect depth is the mean of the average threshold values of the abnormal points in the Pattern Deviation Plot (PDP) shown in figure 4.

DISCUSSION

Synopsis of key findings

This study was undertaken to evaluate the usefulness of FDP to detect early perimetric quadrantic changes as compared to SAP in POAG patients. This study was comparable to a study done by Balwantray C. Chauhan and Chris A. Johnson which shows reduced mean test time with frequency-doubling perimetry as compared with conventional perimetry

The mean threshold in SAP SITA to be significantly higher as compared to FDT Matrix (p<0.001) with a strong correlation between the measurements in both the POAG and control group (r=0.872; p<0.001 and r=0.865; p<0.001 respectively). The explanation for this difference have been given by different studies, which states that marginal locations of the field defects may be perceived as normal when stimuli are larger, whereas smaller stimuli are more likely to be confined to the region of abnormality. Smaller stimuli might be expected to detect the border between the affected and non affected areas more precisely.

There was no significant correlation found between the sensitivity measured by the two methods in the various quadrants. It is possible that such correlation does not exist because the duplicated stimulus is not projected on to all the quadrants considered by standard automated perimetry.

Consistent with the findings reported by Patel et al our results indicate that FDT Matrix delineated smaller and deeper defects than those shown by SAP SITA [17]. It is possible that this finding was secondary to the larger size of the FDT Matrix stimulus or because of less than optimal performance of the normative database. The majority of the subjects in this subgroup had previous experience with SITA, but not with FDT; therefore, this disproportionate experience with one of the technologies could have biased the findings. This also suggests that there is a learning curve for FDT Matrix as is present in SAP.

CONCLUSION

This study supports the utility of FDT Matrix to detect early visual field defects but this device does not detect larger defects as compared with SAP SITA. The defects detected by FDT Matrix are smaller and deeper i.e. detected by greater light intensity than SAP SITA. There was no significant correlation found between the sensitivity measured by the two methods in the various

quadrants. FDT's major contribution may be as a complement to SAP for detecting visual field loss but not as a replacement of SAP.

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