Original Article

# Comparison of visual field test results obtained through Humphrey matrix frequency doubling technology perimetry versus standard automated perimetry in healthy children

*Sibel Kocabeyoglu, Salih Uzun, Mehmet Cem Mocan, Banu Bozkurt[1], Murat Irkec, Mehmet Orhan*

**Aims**: The aim of this study was to compare the visual field test results in healthy children obtained via the Humphrey matrix 24-2 threshold program and standard automated perimetry (SAP) using the Swedish interactive threshold algorithm (SITA)-Standard 24-2 test. **Materials and Methods:** This prospective study included 55 healthy children without ocular or systemic disorders who underwent both SAP and frequency doubling technology (FDT) perimetry visual field testing. Visual field test reliability indices, test duration, global indices (mean deviation [MD], and pattern standard deviation [PSD]) were compared between the 2 tests using the Wilcoxon signed-rank test and paired *t*-test. The performance of the Humphrey field analyzer (HFA) 24-2 SITA-standard and frequency-doubling technology Matrix 24-2 tests between genders were compared with Mann-Whitney *U*-test. **Results:** Fifty-five healthy children with a mean age of 12.2 ± 1.9 years (range from 8 years to 16 years) were included in this prospective study. The test durations of SAP and FDT were similar (5.2 ± 0.5 and 5.1 ± 0.2 min, respectively, $P = 0.651$). MD and the PSD values obtained via FDT Matrix were significantly higher than those obtained via SAP ($P < 0.001$), and fixation losses and false negative errors were significantly less with SAP ($P < 0.05$). A weak positive correlation between the two tests in terms of MD ($r = 0.352$, $P = 0.008$) and PSD ($r = 0.329$, $P = 0.014$) was observed. **Conclusion:** Children were able to complete both the visual test algorithms successfully within 6 min. However, SAP testing appears to be associated with less depression of the visual field indices of healthy children. FDT Matrix and SAP should not be used interchangeably in the follow-up of children.

**Key words:** Frequency doubling technology perimetry, pediatric visual field testing, standard automated perimetry

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Frequency doubling technology (FDT) perimetry measures contrast sensitivity to a low spatial, high temporal frequency stimulus.[1] Humphrey matrix is a second generation FDT perimetry that provides smaller targets in both between 24-2 and 30-2 strategies and a more extensive analysis algorithm. This perimetry test uses a threshold determination procedure based on Bayesian statistics known as zippy estimation by sequential testing,[2] which is similar to the Swedish interactive threshold algorithm (SITA) used by the Humphrey field analyzer (HFA). This algorithm was shown to reduce test duration, and have greater efficiency, and the lower intra-and inter-test variability.[3]

Visual field testing is an important clinical tool in the evaluation of the optic nerve function, retinal, and neurological disorders. Few studies on visual field testing in the pediatric population have been published.[4-8] The aim of the present study was to compare visual field test results in healthy children obtained via FDT Matrix and standard automated perimetry (SAP) and to evaluate the correlations between the FDT Matrix and SAP 24-2 threshold programs.

Departments of Ophthalmology, Hacettepe University School of Medicine, Ankara, Turkey, [1]Selcuklu Medical Faculty, Selcuk University, Konya, Turkey

Correspondence to: Dr. Murat Irkec, Department of Ophthalmology, Hacettepe School of Medicine, Ankara, Turkey. E-mail: mirkec@isnet.net.tr

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## Materials and Methods

The research was designed as a prospective study undertaken at a single academic center. The study protocol adhered to the tenets of the Declaration of Helsinki. Informed consent was provided by all the participants and their parents, and the study protocol was approved by the Institutional Review Board. Study subjects aged from 8 years to 16 years were consecutively included in the study. All participants underwent a complete ophthalmologic examination, including best-corrected visual acuity, cycloplegic refraction, ocular alignment (cover-uncover, and alternate-cover test), sensory binocular function (Titmus-test), slit-lamp examination, and fundus examination. Participants with a best-corrected visual acuity <20/20, a refractive error >0.50 spherical diopters, a history of ocular or systemic disease, ocular surgery, any disease effecting the visual field, as well as those on any systemic or topical medication were excluded from the study.

Only the right eyes of the subjects that fulfilled the inclusion criteria were selected for analysis. Each participant underwent two consecutive visual field tests[1] SAP with the 24-2 SITA-standard strategy (HFA II 750, Carl Zeiss Meditec, Dublin, California, USA) and[2] FDT Matrix perimetry with the Matrix 24-2 threshold program (Humphrey Matrix Visual Field Instrument, Carl Zeiss Meditec, Dublin, Ca; Welch-Allyn, Skaneateles, NY). The tests were performed in random order. Before testing, the task was explained to children following, and a brief training session was held. The participants underwent both the visual field tests on the same day with a 30 min break between the tests.

The reliability criteria for SAP testing were determined as a false-positive response of <33%, false-negative response of <33%, and fixation loses of <20%. FDT Matrix perimetry presented a 5-degree stimulus at a special frequency of 0.5 cycles/degree and a temporal frequency of 18 Hz. The reliability criteria for FDT testing were set as <20% for fixation losses, false-positive, and false-negative responses.

The data obtained were evaluated in collaboration with the department of biostatistics. Data analysis was performed using the SPSS v. 15.0 (Statistical Package for Social Sciences, SPSS Inc. Chicago, IL, United States). Fixation losses, false-positive and false-negative results were compared between the 2 tests using the Wilcoxon signed-rank test, whereas the test duration, mean deviation (MD), and pattern standard deviation (PSD) were compared using the paired sample *t*-test. Correlations between MD and PSD obtained via 2 different visual field tests were analyzed using the Pearson's correlation coefficients and a $P < 0.05$ was accepted as statistically significant.

## Results

The study included 55 children (26 female and 29 male) with a mean age of 12.2 ± 1.9 years (range from 8 years to 16 years). Mean test duration was 5.2 ± 0.5 min and 5.1 ± 0.2 min for HFA and FDT Matrix 24-2, respectively with no statistically significant difference ($P = 0.651$). There were significant differences in fixation losses, false-negative responses, and MD and PSD values between the HFA and FDT perimetry tests ($P < 0.05$) [Table 1]. Fixation losses and the number of false-negative errors were significantly lower in SAP (1.6% ± 5.0% and 1.5 ± 4.8%) as compared to the FDT Matrix test (14.4% ± 7.7%, 4.2 ± 4.5%) ($P < 0.001$ and $P = 0.001$, respectively). The Bland-Altman plot was used to compare the MD and PSD values between two visual field tests [Figs. 1 and 2]. Twenty children were from 8 years to 11 years old, and the other children were from 12 years to 16 years old. Test duration for younger than 11 years of age was 5.2 ± 0.1 min for FDT Matrix and 5.4 ± 0.6 min for SAP, whereas for 12 years of age and older 5.1 ± 0.2 and 5.1 ± 0.4, respectively. A significant shortening in test duration was found with an increasing age for both FDT Matrix and SAP ($P = 0.002$ for FDT Matrix and $P = 0.04$ for SAP, Mann Whitney *U*-test). In addition to the test duration, PSD and false-negative values improved with increasing age for SAP ($P = 0.003$ and $P = 0.041$, respectively). There were no significant differences between genders with respect to test durations, fixation losses, and false-negative errors, MD and PSD values obtained via FDT Matrix and SAP [Table 2]. All print-outs were assessed for the visual field artifacts; no subject demonstrated any evidence of a clinically significant artifact.

## Discussion

SAP is still considered the gold standard in the visual field assessment; however, FDT perimetry is an emerging technique for evaluating M ganglion cell function. Studies have shown that FDT perimetry may be able to detect glaucomatous visual field defects earlier than SAP.[9,10] Although FDT perimetry is used primarily for the detection of glaucomatous visual field loss it has been suggested that visual field defects identified via FDT perimetry may reflect other non-glaucomatous ocular and neurological disorders.[11-13] FDT perimetry has several advantages over SAP, such as tolerance to refractive errors,[14] pupil size and blur, low test-retest variability,[15] having both eyes open during testing, the ability to test with the room lights on, a larger stimulus target, and transportability.

Automated visual field testing is infrequently required in children, and the interpretation of visual field tests in children is limited due to the fact that age-adjusted normative database for children is lacking. As compared to adults, children's attention span is shorter and due to the requirement of prolonged attention and visual fixation,[16] and difficulty learning the task,[17] reliable visual field testing in children is a challenge. Safran *et al*.[18] suggested that a preliminary familiarization phase with a specially designed adaptation program is mandatory for testing children aged less than 7 years.

There are limited numbers of studies that have evaluated visual field testing in the pediatric age group. The present study aimed to compare the visual field test results obtained via FDT Matrix and SAP in healthy children aged from 8 years to 16 years, as well as the correlations between the FDT and SAP 24-2 threshold programs. Both visual field tests were reliable in all the participants; however, the reliability indices (fixation losses and false-negative values) were significantly better with SAP than FDT Matrix ($P < 0.001$). Thus, our results indicate that SAP testing as opposed to FDT Matrix perimetry may be more reliable in children. In support of our findings are those of Nesher *et al*.,[5] in which FDT perimetry was reported being feasible in children > 8 years of age; yet it was associated with the higher rates of fixation losses in the pediatric subjects as opposed to adults. On the other hand, studies on FDT perimetry in children indicate that those aged ≥8 years may be able to perform a reliable FDT.[5,8] In addition, Blumenthal *et al*.[4] observed a correlation between age of children and performance on the FDT threshold test, and suggested that FDT was a clinically feasible method of visual field evaluation in children aged >8 years. In our study, the test durations for the two tests were inversely correlated with increasing age. At older than 12 years of age, a statistically significant shortening in the test duration was found.

The MD and PSD values were found to be significantly lower with FDT Matrix perimetry as compared to SAP ($P < 0.001$). These findings may have been due to the abnormally high fixation losses and false-negative responses. However, as the time duration of both perimetric techniques were similar ($P = 0.651$),

**Table 1: Comparison of the reliability parameters, visual field indices and test duration for Humphrey field analyzer 24-2 SITA-standard and frequency-doubling technology matrix 24-2 tests in healthy children**

| Test parameter | SAP | FDT matrix | P |
|---|---|---|---|
| Test duration (min) | 5.2±0.5 | 5.1±0.2 | 0.651 |
| False positive errors (%) | 5.7±5.4 | 4.5±6.3 | 0.177 |
| False negative errors (%) | 1.5±4.8 | 4.2±4.5 | 0.001* |
| Fixation losses (%) | 1.6±5.0 | 14.4±7.7 | <0.001* |
| Mean deviation (db) | 1.6±1.2 | 4.0±2.0 | <0.001* |
| Pattern standard deviation (db) | 2.1±0.6 | 3.4±0.6 | <0.001* |

SAP: Standard automated perimetry, FDT: Frequency doubling technology, dB: Decibel

**Table 2: Comparison of the performance of Humphrey field analyzer 24-2 SITA-standard and frequency-doubling technology matrix 24-2 tests between genders**

| Test parameter | SAP | | | FDT matrix | | |
|---|---|---|---|---|---|---|
| | Male | Female | *P* | Male | Female | *P* |
| Test duration (min) | 5.2±0.5 | 5.1±0.5 | 0.906 | 5.2±0.2 | 5.1±0.2 | 1.000 |
| False positive errors (%) | 5.9±5.9 | 5.6±5.0 | 0.879 | 5.1±6.8 | 3.8±5.7 | 0.516 |
| False negative errors (%) | 4.3±4.9 | 4.2±4.3 | 0.843 | 1.7±5.2 | 1.2±4.3 | 0.697 |
| Fixation losses (%) | 2.7±6.6 | 0.3±1.9 | 0.105 | 15.7±6.7 | 12.9±8.6 | 0.149 |
| Mean deviation (dB) | 1.7±1.1 | 1.4±1.4 | 0.458 | 3.6±2.3 | 4.4±1.7 | 0.119 |
| Pattern standard deviation (dB) | 2.2±0.6 | 2.1±0.7 | 0.376 | 3.5±0.7 | 3.2±0.6 | 0.044* |

SAP: Standard automated perimetry, FDT: Frequency-doubling technology

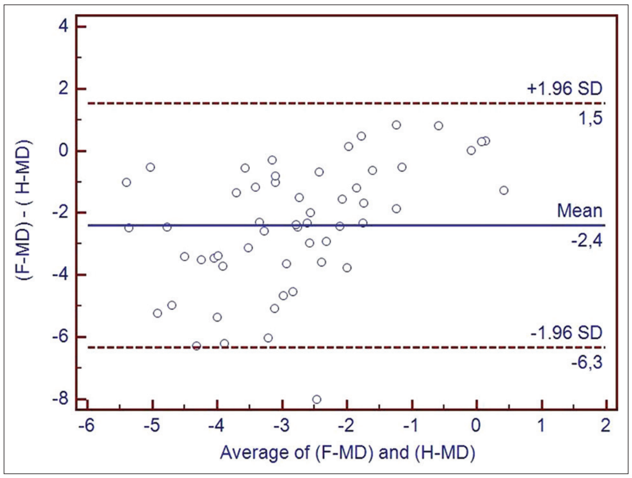


**Figure 1:** Comparison of mean deviation values between two visual field tests using the Bland-Altman plot

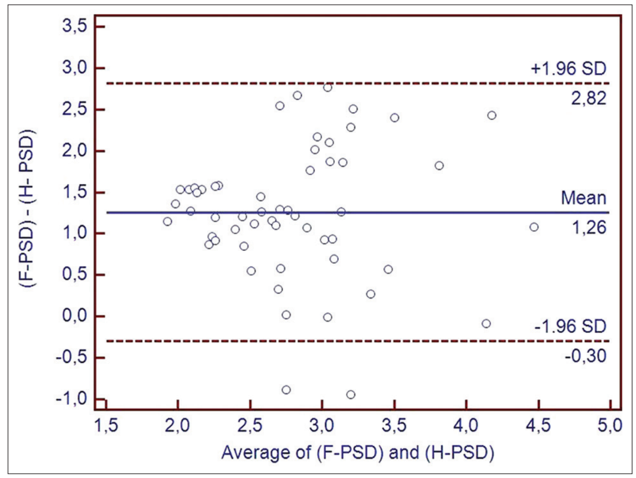


**Figure 2:** Comparison of pattern standard deviation values between two visual field tests using the Bland-Altman plot

the differences in MD and PSD were not thought to be associated with test induced fatigue and loss of attention.

The visual field indices obtained with FDT Matrix perimetry, and SAP exhibited a weak positive correlation [MD ($r$ = 0.352, $P$ = 0.008); PSD ($r$ = 0.329, $P$ = 0.014)] in the present study. Zarkovic *et al*.[19] have reported a strong correlation ($r$ > 0.750) between MD values obtained through SAP on SITA-Standard 24-2 strategy and FDT 24-2 threshold perimetry in patients with glaucoma. Although many data exist on the performance of FDT and SAP in adults, to the best of our knowledge the present study is the first to compare SAP and FDT Matrix perimetry in healthy pediatric population.

The present study has certain limitations, and the study population was small for defining reference values for visual field testing in children. In addition, children underwent both visual field tests only once, and they had no prior experience with visual field testing. Studies have shown that there is a learning effect and test-retest variability with FDT perimetry.[15,20-22] Thus, one can find visual field "improvements" if the same test is repeated on consecutive days. Pierre-Filho *et al*.[20] evaluated the learning effect for the FDT Matrix perimetry using the full-threshold 24-2 strategy when the test was administered 3 times to healthy individuals who had never undergone automated perimetry and reported significant improvements in MD index with repeated testing. Finally, the results of this study may or may not hold true in a population with the visual field defects, however, this issue can be addressed in a future study in which pediatric patients with visual field defects are also recruited.

In conclusion, the results of the present study indicate that both the SAP with SITA 24-2 threshold strategy and FDT Matrix perimetry with 24-2 strategy can be used in children. Although both perimetric techniques exhibited reliable test results and test duration, it must be kept in mind that the two visual field techniques use different scales and principles. In addition, the correlation of MD and PSD was weak between the two tests; therefore, direct comparison of the two visual field tests should be avoided. In pediatric subjects, consistent use of the same perimetric technique for follow-up evaluations is recommended.

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