A COMPARISON OF LIGHT DETECTION THRESHOLDS IN GLAUCOMATOUS VISUAL FIELDS IN SITA-S AND FASTPAC

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Abstract

Purpose: The threshold measurements and the intra-individual inter-test variability of Swedish Interactive Threshold Algorithm–Standard (SITA-S) were studied and compared against Fastpac strategy.

Methods: Ten eyes (six right and four left) of ten experienced patients with glaucomatous optic neuropathy were tested twice with each of the Fastpac and SITA-S strategies using C24-2 grid, standard parameters and default fixation monitoring. Non-parametric two-tailed sign and Friedman tests were used for comparisons.

Results: At normal test locations ($n=177$), Fastpac repeat tests produced mean standard deviation results of $27.38 \pm 2.82 \text{dB}$ and $27.24 \pm 2.90 \text{dB}$ ($p=0.202$). SITA-S re-test results at the identical areas were $28.03 \pm 3.3 \text{dB}$ and $27.63 \pm 4.0 \text{dB}$ ($p=0.061$). SITA-S decibel thresholds averaged 0.38dB higher than Fastpac ($p<0.001$). Fastpac inter-test variability was $1.7 \pm 1.4 \text{dB}$ and SITA-S inter-test variability was $1.8 \pm 2.1 \text{dB}$ ($p=0.733$). At abnormal test locations ($n=343$), Fastpac and SITA-S pointwise results were $19.86 \pm 6.9 \text{dB}$ and $21.04 \pm 6.7 \text{dB}$, respectively, ($p<0.001$) with an average of 1.1dB higher sensitivity recordings within scotomas by the latter. Inter-test fluctuation was $4.4 \pm 4.3 \text{dB}$ for Fastpac and $3.5 \pm 3.9 \text{dB}$ for SITA-S ($p=0.004$). The average test duration was $418 \pm 89$ seconds for 20 Fastpac tests and $403 \pm 80$ for 20 SITA-S tests ($p=0.109$).

Conclusions: SITA-S provided significantly less inter-test intra-individual fluctuation and 1.1dB higher sensitivity within scotomas when compared to Fastpac. The two tests required approximately the same time when full fixation monitoring was employed.

Introduction

The third generation algorithms, Swedish Interactive Threshold Algorithm–Standard (SITA-S) and SITA Fast, and the second generation algorithm, Fastpac, of the Humphrey Visual Field Analyzer were designed to improve patient friendliness via efficiency and reduced patient strain without sacrificing the accuracy of results.

The algorithm accuracy of SITA-S was claimed to be equivalent to the full threshold strategy, and the accuracy of SITA-Fast was said to match Fastpac strategy. Based on those claims, SITA-S should be superior to Fastpac in terms of efficiency

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and informative value of numeric threshold measurements. The purpose of this study was to compare SITA-S algorithm to Fastpac strategy in glaucomatous eyes with respect to numeric threshold content in normal and scotomatous parts of the visual field, intra-observer inter-test variability, efficiency and fatigue prevention.

Patients and methods

Ten eyes (six right and four left) of ten experienced and reliable patients (mean age 64 years, range 43–82 years) with previously established glaucomatous optic neuropathy, were studied. The patients who were enrolled in the study had prior experience with threshold automated perimetry and had demonstrated reliable threshold Statpac test results with reproducible glaucomatous scotomas during at least two of their most recent consecutive routine examinations using the Humphrey Visual Field Analyzer with the standard parameters (fixation losses ≤20% and false negatives and positives ≤33% of total attempts). In each individual, the eye with the more advanced field defect or, in the case of symmetrical involvement, a randomly selected eye, was included in the study. All patients had visual acuity of 20/25 or better with refraction of ≤±6.00 D spherical equivalent and ≤±1.00 D astigmatism, normal pupils (range 3.0-4.5 mm), clear ocular media, no pilocarpine use, and no ocular or systemic disease other than systemic hypertension. A history of past trabeculectomy and/or uncomplicated extracapsular cataract extraction and posterior chamber intraocular lens implantation was allowed.

Following informed verbal consent, the selected eyes of these patients were tested twice with each of the Fastpac and SITA-S strategies using a Humphrey Visual Field Analyzer II Model 750 (Humphrey Instruments, San Leandro, CA). The ‘full threshold’ strategy was excluded to minimize the burden on the patients introduced by its lengthy test duration. The tests were conducted with Goldmann Size III stimulus with the short-term fluctuation option switched off during Fastpac testing, as the short-term fluctuation option was not available for SITA-S. Fixation monitoring was maintained by means of infrared gaze tracking, video camera and blind spot checks as default options throughout all tests. All four tests were administered within the same day with a minimum of 15-minute rest periods between them to reduce any fatigue effect. The order of the tests was arranged so that Fastpac strategy was employed for the first two tests in five patients and SITA-S strategy for the first two tests in the other five patients. For classification purposes, any test point showing a statistically significant deviation from normal (i.e., p<0.05) on the total deviation plot of any one of the two results obtained with Fastpac strategy was regarded as an abnormal area within that eye. All abnormal points on Fastpac results were assumed to represent the scotomas that SITA-S should also detect and map. The test points above and below the physiological blind spot were excluded from the process because false defects are common at these locations.

Results from individual test locations and decibel fluctuations on re-test were studied within the normal and abnormal portions of the visual fields within and between Fastpac and SITA-S strategies. The non-parametric two-tailed sign test for related samples and the Friedman test, the non-parametric equivalent of two-way analysis of variance (ANOVA) for dependent data with non-normal distribution, were used for comparisons of differences between test results. Statistical processing was performed with a commercial software package (SPSS Inc., Chicago, IL) and a microcomputer.
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Results

The visual field test results obtained from ten eyes were evaluated cumulatively for each of the Fastpac and SITA-S tests. Abnormal (n=343) and normal (n=177) test locations in all eyes were studied separately to establish the inter-test variability in decibel scores within each strategy.

Test locations with age-expected normal sensitivities determined by the two Fastpac tests were studied first. At normal test locations (n=177), Fastpac repeat tests produced average pointwise results of 27.38 ± 2.82dB (mean and standard deviation) (range 19-32dB; 95% C.I. 26.8–27.9dB) and 27.24 ± 2.90dB (range 16-34dB; 95% C.I. 26.7–27.8dB) for the first and second tests, respectively (p=0.202), indicating no significant exhaustion with retest (Fig. 1). First and second SITA-S test results at the identical normal areas were 28.03 ± 3.3dB (range 13-34dB; 95% C.I. 27.4–28.7dB) and 27.63 ± 4.0dB (range 5-33dB; 95% C.I. 26.6–28.1dB) (p=0.061), again indicating no significant fatigue effect (Fig. 2). SITA-S gave decibel thresholds at normal locations that averaged 0.38dB higher than those obtained using Fastpac (p<0.001).

At abnormal test locations (n=343), the pointwise averages of first and second Fastpac were 19.86 ± 6.9dB (range 0-32dB; 95% C.I. 19.1–20.6dB) and 19.02 ± 6.7dB (range 0-31dB; 95% C.I. 18.3–19.7dB), respectively (p<0.001), indicating an average of -0.83dB significant depression on retest due to possible fatigue (Fig. 3). First and second SITA-S test results at the identical scotomatous areas were 21.04 ± 6.7dB (range 0-32dB; 95% C.I. 20.3–21.8dB) and 20.02 ± 7.0dB (range 0-32dB; 95% C.I. 19.3–20.8dB), respectively (p<0.001) (Fig. 4). SITA-S generated an average of 1.1dB higher sensitivity in scotomas plotted by Fastpac (p<0.001). The fatigue-related mild but significant reduction in the average sensitivity within scotomas was not significantly different between Fastpac and SITA-S (p=0.054).

Fig. 1. The decibel threshold values at each test location in normal areas with repeat Fastpac tests.
Fig. 2. The decibel threshold values at each test location in normal areas with repeat SITA-S tests.

Fig. 3. The decibel threshold values at each test location in abnormal areas with repeat Fastpac tests.
At abnormal test locations, the average inter-test fluctuation component was $4.4 \pm 4.3\, \text{dB}$ (95% C.I. 3.9–4.8dB; 95 percentile 14.8dB; range 0–23dB) for Fastpac and $3.5 \pm 3.9\, \text{dB}$ (95% C.I. 3.1–4.0dB; 95 percentile 11.8dB; range 0–29dB) for SITA-S. The 0.9dB reduction in pointwise inter-test fluctuation observed with SITA-S in comparison to Fastpac was significant ($p=0.004$).

In the normal parts of the visual field, Fastpac inter-test variability was $1.7 \pm 1.4\, \text{dB}$ (95 C.I. 1.5–1.9dB; 95 percentile 4.0dB; range 0–7dB) while SITA-S inter-test variability was $1.8 \pm 2.1\, \text{dB}$ (95% CI 1.5–2.2dB; 95 percentile 5.0dB; range 0–21dB). Although both strategies displayed significantly less fluctuation within the normal portions compared to abnormal locations of the field ($p<0.001$), no significant differences existed between the results using different strategies in the normal parts of the field ($p=0.733$).

All tests produced normal reliability indices, and no further evaluation of these indices was performed. The average test duration was $418 \pm 89$ seconds (range 333–569 seconds) for 20 Fastpac tests and, $403 \pm 80$ (range 329–545 seconds) for 20 SITA-S tests ($p=0.109$). The average time saved using SITA-S was 15 seconds (3.7%).

**Discussion**

The SITA algorithm, a third generation threshold test strategy, estimates the visual sensitivity by construction based on prior knowledge, continuous estimation of thresholds and measurement errors, interruption at previously determined level of accuracy at individual points, estimation of false answer frequencies, including reaction times and post-processing of all results. Fastpac, which was first introduced in Computer Perimeter and re-introduced as a second generation algorithm, crosses the threshold once with 3dB steps. The claimed algorithm accuracy of SITA-S as being the equivalent of the full threshold and consequently
superior to Fastpac strategy in threshold estimates\(^1\), was verified with a minimum amount of burden on the patients in this study by comparing SITA-S to Fastpac. Although the main purpose of introducing SITA was to enable further reduction in test times\(^5\), no significant time-saving feature was observed in this study when SITA-S was compared to Fastpac. This may be due to the fact that stringent fixation monitoring options were kept active during all tests, masking the time-saving ability of SITA-S that might otherwise occur in the absence of full fixation monitoring.

A direct point-by-point comparison to Fastpac results indicated that, on average, the numeric threshold estimates provided by SITA-S tended to be significantly higher than those measured by Fastpac, specifically, 0.38dB in normal areas and 1.1dB in abnormal locations. Although the new SITA-S strategy was intended to replace the standard full-threshold algorithm of the Humphrey VFA, based on simulations rather than actual patient data\(^1\), the threshold overestimation it provided in this study may indicate that this is not the case (Fig. 5). The importance of this may be more relevant when a comparison of results from different algorithms is attempted in routine clinical follow-up of an individual patient. The screening sensitivities (true and false-positive scotoma detection rates) of algorithms may be more comparable with the use of age-related normative data. The description of scotoma detection rates of different algorithms was beyond the scope of this study and requires further research on a larger scale.

Neither strategy displayed any significant fatigue in the normal parts but significant and comparable fatigue effect in the abnormal parts of the visual field. The amount of fatigue, i.e., the progressive decline in the light detection sensitivity on repeat testing, was \(-0.60\)dB and \(-0.14\)dB (\(p=0.168\)) at normal test locations using SITA-S and Fastpac, respectively. At scotomatous locations, the fatigue was more obvious and significant, amounting to \(-1.02\)dB with SITA-S and \(-0.83\)dB with Fastpac; there was no apparent significant difference between the algorithms in that respect (\(p=0.192\)). The difference between the algorithms with reference to the fatigue effect was insignificant in the sample size employed. The differences observed between the algorithms are unlikely to be due to the order of the tests, because this was controlled and standardized. Also, the lack of significant fatigue in the normal parts of the field indicates that the rest periods provided between the tests were effective in preventing patient exhaustion.

Long-term fluctuation is defined as the variation in the numeric dB threshold values between two separate examinations and is thought to be due to the physiological state of the visual system exclusive of organic change or identifiable artifacts. Both strategies resulted in significantly less and equal amounts of fluctuation within the normal portions of the field in comparison to that in the abnormal areas of the field. One of the more interesting findings of the study was that SITA-S displayed a smaller amount (i.e., \(0.9\)dB on average) of long-term fluctuation than that of Fastpac in the areas identified as scotomatous by the latter strategy.

In summary, SITA-S is equally as efficient as Fastpac when full fixation monitoring is engaged. SITA-S provides higher numeric threshold values at both normal and abnormal portions of the field. SITA-S displays a smaller amount of re-test fluctuation than Fastpac in the abnormal visual field. In conclusion, SITA-S appears to be equivalent to Fastpac in terms of efficiency, informational content and fatigue prevention, while reducing re-test fluctuation in scotomas. The inherently smaller amount of long-term fluctuation may render SITA-S more useful and preferable in follow-up of visual field defects, although the field results from SITA-S may not be directly comparable to Fastpac results.
Fig. 5. a. The gray scale, pattern deviation numeric results and their statistical significance with Fastpac in six glaucomatous eyes.
Fig. 5. b. The gray scale, pattern deviation numeric results and their statistical significance with SITA-S in the same eyes.
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References