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# A Comparative Study between Swedish Interactive Thresholding Algorithm Faster and Swedish Interactive Thresholding Algorithm Standard in Glaucoma Patients

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## Abstract

**Purpose:** To compare the results of the new strategy Swedish Interactive Thresholding Algorithm (SITA) Faster to the results of SITA Standard in patients with glaucoma.

**Methods:** This was a cross-sectional study of 49 patients with glaucoma and previous experience with standard automated perimetry. Two consecutive tests were performed in random order, one with SITA Standard and another one with SITA Faster, in the studied eye of each patient. Comparisons were made for test time, mean deviation (MD), visual field index (VFI), and number of depressed points in pattern deviation map and total deviation map for every level of significance.

**Results:** The average test time was 56% shorter with SITA Faster ($P < 0.001$). The intraclass correlation coefficient (ICC) for MD and VFI showed excellent agreement between both strategies, ICC = 0.98 (95% confidence interval [CI]: 0.96, 0.99) and ICC = 0.97 (95% CI: 0.95, 0.99), respectively. For the number of depressed points in total deviation map and pattern deviation map, ICC demonstrated good agreement with values between 0.8 and 0.95.

**Conclusions:** Our study shows that SITA Faster is a shorter test with strong agreement with SITA Standard parameters. These results suggest that SITA Faster could replace SITA Standard for glaucoma diagnosis.

**Keywords:** Glaucoma, SITA Faster, Visual field

## INTRODUCTION

Computerized threshold perimetry test is the gold standard method for diagnosis and follow-up of glaucoma functional loss.[1,2] Swedish Interactive Thresholding Algorithm (SITA) strategies were developed at the end of the 1980s with the aim to replace the earlier full threshold test, reducing test time in half without worsening sensitivity percentages. Nowadays, the most widely used strategy is SITA Standard.[3] This strategy, contrary to the full threshold, uses sensibility results of the nearby locations to perform probability calculations in order to estimate threshold values.[4-6]

Shortly after SITA Standard was introduced, another strategy of the SITA family was created, SITA Fast, to obtain a shorter test. This objective was achieved by presenting starting stimuli closer to the expected threshold and because stimulus staircases were interrupted at an earlier stage by increasing the error-related factor cut-off. SITA Fast saves roughly 2–3 min in comparison to SITA Standard; however, it accepts lower

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accuracy of test results. For this reason, this time-saving was not considered worthwhile by many clinicians.[7,8]

A new strategy, SITA Faster, has recently been developed in search of a shorter test without having a significant effect on accuracy. Several modifications were performed to SITA Fast to produce SITA Faster, including changing starting stimulus intensity at primary test points, reducing staircase reversals at primary test points, and suppressing false-negative and blind-spot catch trials. A paper by Heijl *et al*.[9] explains the development of SITA Faster and describes the seven modifications that were made to SITA Fast to obtain this strategy.

The aim of our study is to compare the new strategy for visual field testing, SITA Faster, available in the Humphrey Field Analyzer III (Carl Zeiss Meditec, Dublin, CA), to SITA Standard, which is considered the gold standard strategy.[10,11] There are few published papers comparing these strategies. Additionally, one distinction of our study is the singular inclusion of glaucoma patients with visual field alterations.

## METHODS

This was a cross-sectional study carried out in our two institutions. It included patients over 18 years old with glaucoma and previous experience in automated perimetry. Only patients meeting Hodapp–Parrish–Anderson (HPA) minimum criteria for diagnosing acquired glaucomatous damage[12] in SITA Standard test were enrolled. Therefore, they had to fit two out of these three statements:

- Presence of a cluster of three or more nonedge points on the pattern deviation probability plot depressed $P < 5\%$, with at least one point $P < 1\%$
- Pattern standard deviation $P < 5\%$
- Glaucoma hemifield test results outside normal limits.

Patients needed a visual acuity of at least 20/40, and the visual field test (VFT) performed had to be reliable to be accepted. For SITA Standard VFTs, only a fixation loss rate of <30% and false-negative and false-positive rates under 15% were considered. As mentioned previously, seven modifications were made to SITA Fast to produce SITA Faster, two of them concerning reliability indices. As a matter of fact, false-negative and blind-spot catch trials were eliminated.[9] Therefore, the only exclusion criterion regarding VFT reliability was a false-positive rate over 15% for SITA Faster tests. Furthermore, as the number of fixation losses could not be recorded, patient's fixation was required to be assessed by the gaze tracker. The technician was forced to stop and repeat the test if fixation was lost for three times or more during the 1st min of the test.

Additionally, only patients with a refractive error between −5 and +5 diopters of spherical power, under 3 diopters of cylinder power, and more than 2 mm of pupil diameter were included. The presence of other ocular pathologies that could influence VFT results, except for cataract, was a reason for exclusion. If both eyes were eligible, the study eye was selected randomly.

After signing informed consent forms, participating patients underwent two consecutive VFTs only in the studied eye, administered in random order, one with the SITA Standard strategy and another one with SITA Faster. A 5-min break was allowed between the tests.

The same model of Humphrey Field Analyzer, HFA III 840 (Carl Zeiss Meditec, Dublin, CA), was used in both institutions. VFTs were performed by experienced perimetrists and in rooms under the same conditions. To homogenize the information given to patients, they received a prepared sheet of written instructions. First, patients were refracted and near vision correction was used to take the test. The perimetrist monitored the patient throughout the test, looking for appropriate gaze fixation and repeating instructions if the reliability indices worsened.

Once both tests were completed, we registered the reliability indices (fixation loss, false-negative, and false-positive rates), pupil diameter, test time, mean deviation (MD), visual field index (VFI), and number of depressed points in the total deviation map and the pattern deviation map. The number of depressed points was clustered according to the level of significance. Therefore, the $P < 5\%$ group included all depressed points; the $P < 2\%$ group joined depressed points at $P < 2\%$, $P < 1\%$, and $P < 0.5\%$; the $P < 1\%$ group included $P < 1\%$ and $P < 0.5\%$ points; and the $P < 0.5\%$ group had only points corresponding to this level of significance. According to the glaucoma severity, VFT was classified in three stages following HPA criteria:[12] mild, moderate, and severe glaucoma. Finally, SITA Faster tests were also reviewed in order to verify if HPA minimum criteria for acquired glaucomatous damage[12] were met.

This study complied with the tenets of the Declaration of Helsinki and was approved by the ethical committee of both participating hospitals.

### *Statistical analysis*

As the study is based on a correlation analysis between both visual field strategies, a calculation was made to determine the sample size needed for the intraclass correlation coefficient (ICC) estimation. Considering that we wanted to achieve a desirable ICC above 0.8, a sample size of 49 patients was needed for a confidence level of 95% and a power of 80% in the bilateral case. Conversely, assuming that SITA Faster is not superior to SITA Standard, a unilateral test can be considered. In this instance, and maintaining the other assumptions invariable, a sample size of 39 patients would be required. These sample sizes were determined using the R ICC. Sample.Size package (https://cran.r-project.org/web/packages/ ICC.Sample.Size/ICC.Sample.Size.pdf accessed November 30, 2018). Moreover, according to existing publications, a rate of 30% for nonreliable VFTs was expected,[13] which had to be added to the mentioned sample size to determine the number of patients needed for recruitment.

Result parameters of both tests were compared to analyze the level of agreement between strategies. Moreover, test times were

compared to prove if SITA Faster was a shorter test. For the initial statistical analysis, quantitative variables were described through mean and standard deviation. A frequency table (number and percentage) was used to describe the qualitative variables. The Shapiro–Wilk test was used to check the normal distribution of data. Test times were not normally distributed. Therefore, test time results were presented in terms of median and interquartile range values for each strategy. Differences on test time between the strategies were checked through paired Wilcoxon signed-rank test. Subsequently, intermethod agreement of SITA Faster versus SITA Standard measures was checked through ICC. The choice of ICC was based on single rating, absolute agreement, and two-way random-effects model. Criteria explained in Koo and Li were followed.[14] In terms of the benchmark scale used to evaluate the ICC, values below 0.5 were considered to indicate poor agreement and those between 0.5 and 0.7, moderate agreement. For good agreement, an ICC between 0.75 and 0.9 was required and for excellent agreement, above 0.9.[11] The agreement between methods was also assessed through Bland–Altman plots and their elements: mean of differences or bias and limits of agreement. Finally, differences between both strategies in proportion of visual fields meeting HPA minimum criteria for glaucoma damage[12] were checked through Z-test. P values lower than 0.05 were considered statistically significant. SPSS, version 23.0 for Windows (IBM, Armonk, NY, USA), as well as STATA, version 15 (StataCorp, College Station, TX, USA), and the online calculator Epitools (https://epitools.ausvet.com.au/ztesttwo accessed August 20, 2020*)*, were used for the statistical analyses.

# RESULTS

Sixty-three patients were enrolled in the study; however, 14 of them had to be excluded because they did not meet the reliability index criteria: 8 because of fixation losses in SITA Standard, 4 because of false negatives in SITA Standard, and 2 because of false positives in SITA Faster.

Therefore, a total of 49 patients with a mean age of 72 ± 10.49 years (range, 28–87) were analyzed for the study. Fifty-three percent of them were male. Regarding the severity of glaucoma, there were 25 patients with mild glaucoma, 14 with moderate glaucoma, and 10 with severe glaucoma. The average MD in SITA Standard test for the 49 participants was −8.12 ± 7.22 dB.

The median values and interquartile ranges for test times were 371 (332–424) s for SITA Standard and 163 (137–186) s for SITA Faster. This difference was statistically significant ($P < 0.001$) and represents a reduction of 56% in the test time. Time results are shown in Figure 1, with higher times for SITA Standard. Moreover, the best times in both strategies were found in visual fields with less damage, namely with higher VFI, and test times increased as VFI worsened.

The average MD for SITA Standard was −8.12 ± 7.22 dB and −7.63 ± 7.07 dB for SITA Faster. The average VFI was 77% ± 23% for SITA Standard and 79% ± 22% for SITA Faster. ICCs for MD and VFI were 0.98 (95% confidence interval [CI]:
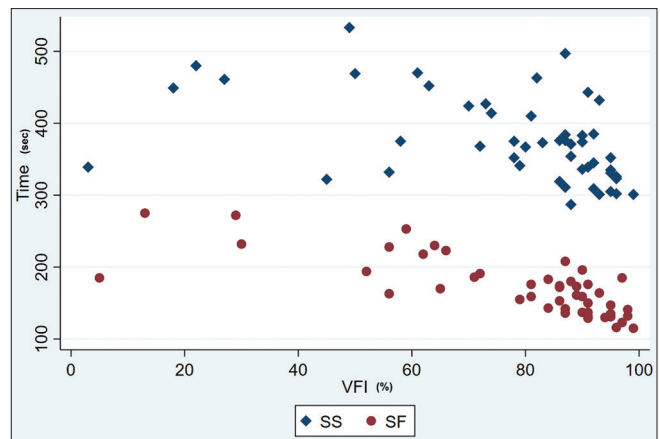


**Figure 1:** Time results of each patient with Swedish Interactive Thresholding Algorithm (SITA) Standard and SITA Faster based on their visual field index

0.96, 0.99) and 0.97 (95% CI: 0.95, 0.99), respectively, which indicates excellent agreement between both strategies.

Regarding the number of depressed points in total deviation map and in pattern deviation map, the agreement was good for all levels of significance, with ICC values between 0.8 and 0.95. Table 1 shows all mean values and ICCs with the corresponding 95% CI for all the studied parameters.

Bland–Altman plots were designed to display the level of agreement between all parameters [Figure 2]. The plots showed a mean difference of −0.5 (95% CI: −3.3–2.3) dB in the MD and a difference of −2 (95% CI: −11.3–7.3) in the VFI.

Finally, 48 out of 49 (97.9%) of the SITA Faster tests met HPA minimum criteria for glaucoma diagnosis.[12] The test that did not conform to the mentioned criteria was a mild glaucoma with a MD better than − 0.50 dB in both strategies. All 49 SITA Standard tests (100%) meet HPA criteria, as it was an inclusion request. These differences were not statistically significant ($P = 0.315$).

# DISCUSSION

Our study demonstrates that SITA Faster significantly shortens test time in comparison to SITA Standard. Hence, the changes made to SITA Fast in order to produce a faster test have proven to be effective. Specifically, our work evidences a reduction of 56% in the test time. These findings are consistent with the three studies already published about SITA Faster by Phu *et al.*,[15] Heijl *et al.*,[9] and Lavanya *et al.*[16] In the former, test times are even compared taking into account the number of unreliable test for each strategy. That study showed that SITA Faster had a higher number of unreliable tests. Nevertheless, the achieved reduction in time remained significant, considering that more tests had to be performed with this strategy to obtain the same proportion of reliable tests as with SITA Standard.

Obtaining a shorter test may improve patients' experience during the test, since it is considered the hardest part of the

**Table 1: Averages of mean deviation, visual field index, and number of depressed points in Swedish Interactive Thresholding Algorithm (SITA) Standard and SITA Faster and results of the intraclass correlation coefficient**

| Parameter | Mean±SD | | ICC (95% CI) |
|---|---|---|---|
| | SITA Standard | SITA Faster | |
| MD (dB) | 8.12±7.22 | 7.63±7.07 | 0.98 (0.96-0.99) |
| VFI (%) | 77±23 | 79±22 | 0.97 (0.95-0.99) |
| Depressed points (*P*<5% TDM) | 30.57±14.67 | 29.67±14.16 | 0.92 (0.87-0.96) |
| Depressed points (*P*<2% TDM) | 25.22±15.81 | 23.43±15.10 | 0.93 (0.87-0.96) |
| Depressed points (*P*<1% TDM) | 21.29±16.11 | 19.31±15.46 | 0.95 (0.9-0.97) |
| Depressed points (*P*<0.5% TDM) | 18.0±16.14 | 13.92±14.35 | 0.9 (0.69-0.96) |
| Depressed points (*P*<5% PDM) | 20.29±8.0 | 19.0±8.46 | 0.8 (0.66-0.88) |
| Depressed points (*P*<2% PDM) | 16.27±8.17 | 14.96±8.76 | 0.88 (0.78-0.93) |
| Depressed points (*P*<1% PDM) | 13.42±8.55 | 12.04±8.65 | 0.91 (0.83-0.95) |
| Depressed points (*P*<0.5% PDM) | 10.62±8.28 | 8.71±8.26 | 0.89 (0.75-0.95) |

SITA: Swedish Interactive Thresholding Algorithm, SD: Standard deviation, ICC: Intraclass correlation coefficient, CI: Confidence interval, TDM: Total deviation map, PDM: Pattern deviation map, MD: Mean deviation, VFI: Visual field index
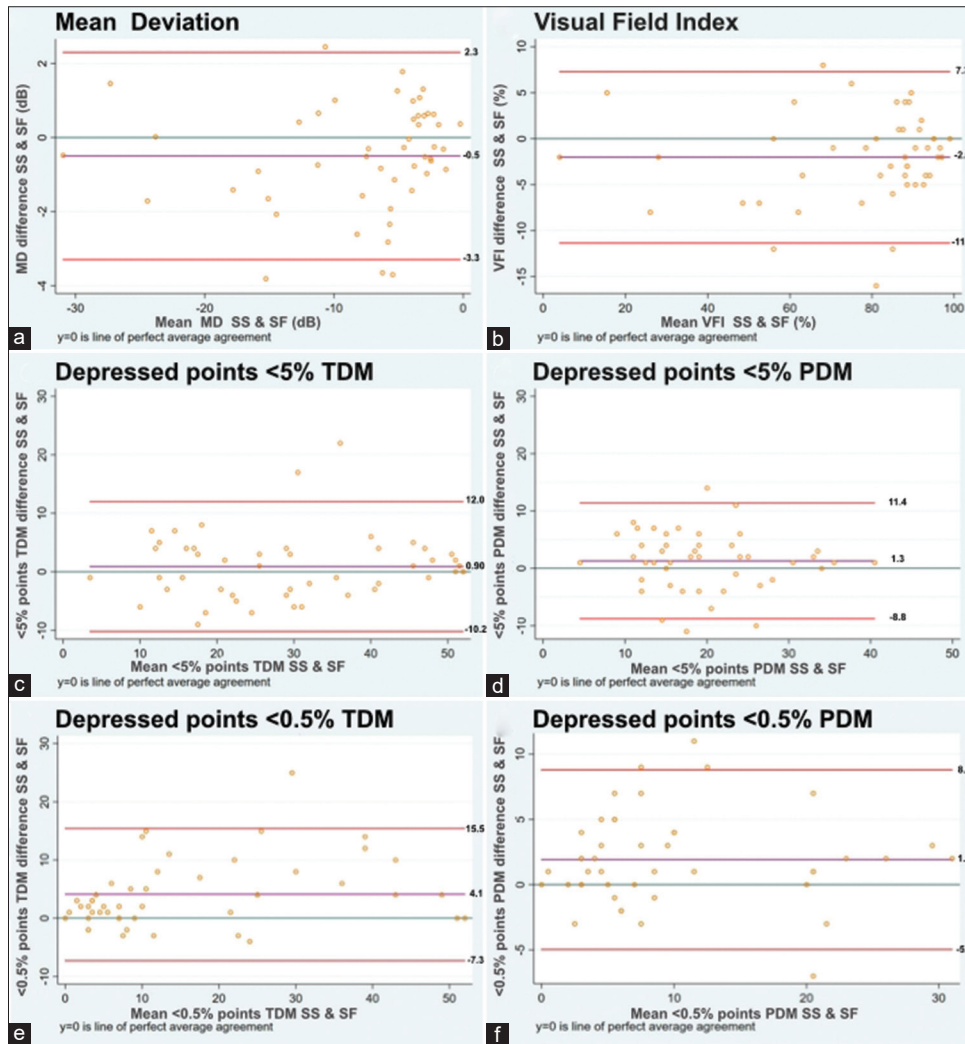


**Figure 2:** a) Bland-Altman plot of the differences in mean deviation (MD) between Swedish Interactive Thresholding Algorithm (SITA) Faster and SITA Standard. The purple line shows the mean difference between the two strategies, and the red lines mark the limits of agreement for 95% confidence intervals. b) Bland-Altman plot of the differences in visual field index (VFI) between SITA Faster and SITA Standard. c) Bland-Altman plot of the differences in the number of depressed points <5% in total deviation map (TDM) between SITA Faster and SITA Standard. d) Bland-Altman plot of the differences in the number of depressed points <5% in pattern deviation map (PDM) between SITA Faster and SITA Standard. e) Bland-Altman plot of the differences in the number of depressed points <0.5% in TDM between SITA Faster and SITA Standard. f) Bland-Altman plot of the differences in the number of depressed points<0.5% in PDM between SITA Faster and SITA Standard.

examination by most glaucoma patients.[17-19] Given the fact that VFT requires a patient's attention because the subject has to actively respond to appearing stimuli by pressing a button, more motivated patients could lead to better reliability rates. Furthermore, shorter test times can help increase the number of patients tested per day, reducing the backlog in health-care systems.

Our results indicate that there is a very good agreement between SITA Faster and SITA Standard parameters, especially in terms of MD and VFI, where the agreement was excellent. These findings are consistent with the three previously published studies mentioned above.[9,15,16] Thereby, it is reasonable to conclude that SITA Faster could replace SITA Standard for glaucoma diagnosis.

Moreover, no differences were found between percentages of VFTs meeting HPA minimum criteria for glaucomatous damage.[12] Nevertheless, one of SITA Faster tests, which belonged to the mild glaucoma group, failed in diagnosing glaucoma. Thereby, caution should be taken when using this test for glaucoma diagnosis in mild glaucoma patients or glaucoma suspects. More studies, including healthy and mild glaucoma patients, should be conducted in order to determine if SITA Faster sensitivity is comparable to SITA Standard. Furthermore, our Bland–Altman plots exhibit small acceptable differences between both strategies, even though the limits of agreement are wider than expected.

One of the strengths of our study is the singular inclusion of glaucoma patients with visual field alterations. The previous publications of SITA Faster, by Heijl *et al.*,[9] Phu *et al.*,[15] and Lavanya *et al.*,[16] also included patients with glaucoma that had clear glaucoma damage in the optic nerve but normal visual fields. Our average MD was − 8.12 dB in the SITA Standard test, whereas it was − 6.44 dB in Heijl's study, −7.3 dB in Lavanya's study, and − 2.02 dB in Phu's study. In the latter, only 21% of the patients had moderate to advanced glaucoma. Mixing normal and damaged visual fields in the same group analysis can lead to erroneous conclusions of agreement between strategies. Normal visual fields have MD close to zero and VFI around 100%, with a minimum number of statistically depressed points. As these values are expected in both strategies, it is likely that the statistical analysis will produce no differences between tests if the study includes normal fields in the glaucoma group. The overriding question was whether the parameters were comparable in damaged visual fields. Certainly, it is also valuable to verify that the new strategy is valid for normal fields, although segregating these patients in different groups could improve the reliability of the analysis.

Studies with larger samples and comparing both tests with each stage of glaucoma independently should be made to corroborate our results. Furthermore, considering the fact that only glaucoma patients were included in our study, our findings are not applicable to other ocular pathologies. Moreover, longitudinal studies focusing on SITA Faster repeatability

and reproducibility and on the capacity of the test to detect progression in comparison to SITA Standard are necessary to validate the test for glaucoma follow-up. If further studies demonstrate that SITA Faster can be implemented in these patients, their monitoring could be improved, as a shorter test may allow increasing frequency testing. Moreover, performing more tests leads to earlier detection of glaucoma progression.[20] Chauhan *et al.*[21] recommended in their paper to perform six VFTs in the first 2 years after glaucoma diagnosis to rule out the presence of rapid progression (−2 dB/year or worse) and to establish a good baseline for future progression analysis. However, recently published data reveal that these recommendations are not being followed in the clinical practice. In fact, the median number of visual field examinations performed in the first 2 years is only of 2 or 3 tests.[22] Establishing the rate of progression in a timely manner is vital to detect which patients are at risk of developing visual impairment early enough to maintain patients' quality of life.[23,24]

Importantly, if SITA Faster is validated in the future for glaucoma follow-up, caution should be taken in patients previously followed with other strategies. A recent change of strategy can lead to a misinterpretation of a false progression when interpreting a guided progression analysis.

To summarize, our study demonstrates that SITA Faster offers a shorter VFT and very good agreement with SITA Standard so that it could be used for glaucoma diagnosis.

### *Conflicts of interest*
There are no conflicts of interest.

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