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Original Article

The Conventional Head Impulse Test Versus the Suppression Head Impulse Test: A Clinical Comparative Study

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BACKGROUND: The suppression head impulse test is a new paradigm of the head impulse test, recently introduced for clinical use. The aim of this study was to assess the importance of the suppression head impulse paradigm in evaluating vestibular function.

METHODS: This comparative study was conducted from June 2020 to June 2022. The ears of the participants were divided into 2 groups: (i) ears with vestibular weakness and (ii) healthy controls. All participants underwent video head impulse tests at the time of presentation with both conventional head impulse paradigm and suppression head impulse paradigm, performed by the same examiner. The results of the 2 tests were compared, and the correlation between the corresponding parameters obtained (vestibulo-ocular reflex gain and saccades) was examined.

RESULTS: Ninety-five participants were included in the study (190 ears) with a mean age of 42.2 ± 12.6 years. Forty-six ears had vestibular weakness, and 144 were healthy controls. The suppression head impulse paradigm test showed a significantly lower vestibulo-ocular reflex gain than the head impulse paradigm in both groups. A positive correlation emerged between the vestibulo-ocular reflex gain measured with both paradigms. Regarding the saccades, a negative correlation was observed between the overt saccades latency and amplitude measured with both paradigms.

CONCLUSION: The new suppression head impulse paradigm complements the head impulse paradigm for a better evaluation of the vestibular function. The inconsistency of covert saccades in suppression head impulse paradigm makes it superior to head impulse paradigm in measuring vestibulo-ocular reflex gain, especially in patients with vestibular loss.

KEYWORDS: Head impulse test, vestibulo-ocular reflex, saccades

INTRODUCTION

The head impulse test (HIT) is the only vestibular test that measures the vestibulo-ocular reflex (VOR) gain in the frequencies of daily living, ranging from 5 to 8 Hz.[1] MacDougall et al[2] introduced a new test protocol for video head impulse tests (vHIT) called suppression head impulse paradigm (SHIMP) in 2016. During a conventional HIT, using the head impulse paradigm (HIMP), the patient is told to maintain their gaze on a wall-mounted mark while the clinician pushes the patient's head suddenly in the direction of the tested ear. Conversely, in SHIMP tests, the patient wears the goggle from which a laser dot is emitted, and the patient is told to maintain gaze on this dot while it is moving on the wall. Simultaneously, the clinician performs a short, sudden head impulse.[2]

During HITs, a "compensatory" saccade (refixation eye movements) is generated in the direction opposite to that of the head impulses. Conversely, an "anti-compensatory" saccade is generated in the same direction as that of head impulses.[3] In healthy patients, no compensatory saccades are observed using the HIMP test, whereas large anti-compensatory saccades are observed with the SHIMP. In patients with an imperfect VOR, compensatory saccades appear with the HIMP, and anti-compensatory saccades are nonexistent using the SHIMP.[3]

The type of saccades measured with the HIMP reveals the severity of the vestibular loss.[4] In comparison, saccades observed with the SHIMP signify a residual vestibular function.[5] Additionally, the SHIMP makes the VOR gain calculation more accurate. Unlike in the

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HIMP, saccades with the SHIMP rarely appear before reaching zero velocity (end of the head movement).[4,5]

This study aimed to assess the importance of the SHIMP test in evaluating vestibular function by comparing the results of HITs using HIMP and SHIMP performed on the same subjects and examining the correlation between the parameters obtained with the 2 types of tests.

METHODS

Subjects

This comparative study was conducted from June 2020 to June 2022 and aimed to compare the results of HITs using conventional HIMP and SHIMP. The study was approved by the Ethics Committee of the Faculty of Medicine at our institution (IRB number: 00012098). All patients provided written informed consent.

The participants' ears were divided into 2 groups: (i) ears with vestibular loss based on the low VOR gain (<0.7) measured with both HIMP and SHIMP in the lateral plane, according to the manufacturers of otometrics, and (ii) healthy controls. Patients with other vestibular or neurological disorders were excluded from the study.

Patients with dizziness symptoms whose vestibular syndrome occurred within a week with no complaints of hearing loss were recruited. Grouping was done according to a final clinical diagnosis. Then, 30 patients (30 ears) with unilateral vestibular neuritis and 8 patients (16 ears) with bilateral vestibular loss were selected for the study. Total 38 patients (46 ears) with vestibular loss based on the low VOR gain.

Video Head Impulse Tests

All participants underwent vHIT at the time of presentation with conventional HIMP and SHIMP performed by the same qualified examiner. For the HIMP test, the participants were instructed to fixate their eyes on a wall-mounted target at 1 m, while for the SHIMP, they fixed their gaze on the wall projection of a goggle-mounted laser. Ten impulses for each lateral canal were recorded for both paradigms.

Statistical Analysis

The statistical analysis was performed using IBM Statistical Package for the Social Sciences software version 20.0 (IBM SPSS Corp.; Armonk, NY, USA). The continuous data were tested for normality using the Shapiro–Wilk and Kolmogorov–Smirnov tests. The quantitative data are expressed as a range (minimum and maximum), mean, standard deviation, and median.

For non-normally distributed quantitative variables, the Wilcoxon signed-rank test was used to compare the results from HIMP and SHIMP tests. In contrast, the Bland–Altman plot and Spearman's correlation coefficient were used to evaluate the agreement between HIMP and SHIMP. The significance of the results obtained was determined at the 5% level.

RESULTS

In total, 95 participants (190 ears) were included in this study, 60 women and 35 men, with a mean age ($\pm$standard deviation) of 42.2 $\pm$ 12.6 years. The group with vestibular loss comprised 38 patients: 30 with unilateral loss and 8 patients with bilateral loss (46 ears) with a mean age 40.99 $\pm$ 12.53 and the healthy controls consist of 57 subjects (144 ears including the normal ears of patients with unilateral loss) with a mean age 45.61 $\pm$ 12.97. The group with vestibular loss consists of 29 females and 9 males. The healthy control consists of 31 females and 26 males.

Vestibulo-Ocular Reflex Gain Comparison

The SHIMP test showed a significantly lower VOR gain than the HIMP in both groups. In the group with vestibular loss, the mean VOR gain evaluated using HIMP and SHIMP was 0.63 $\pm$ 0.20 and 0.58 $\pm$ 0.22, respectively ($P = .007$), whereas in the control group, it was 1.02 $\pm$ 0.18 and 0.95 $\pm$ 0.21, respectively ($P < .001$).

In both groups, a moderate correlation was found between the results of the 2 paradigms regarding the VOR gain ($r = 0.6$, $P < .001$; Figure 1).

Saccades Parameters Comparison

Regarding the covert saccades, the latency measured by HIMP was correlated positively with that measured by SHIMP ($r = 0.31$, $P = .03$), whereas the amplitude of the covert saccades measured by HIMP was not correlated with that measured by SHIMP. ($r = -0.12$, $P = .3$).

In contrast, a strong negative correlation was noted between both the amplitude and latency of overt saccades measured using HIMP

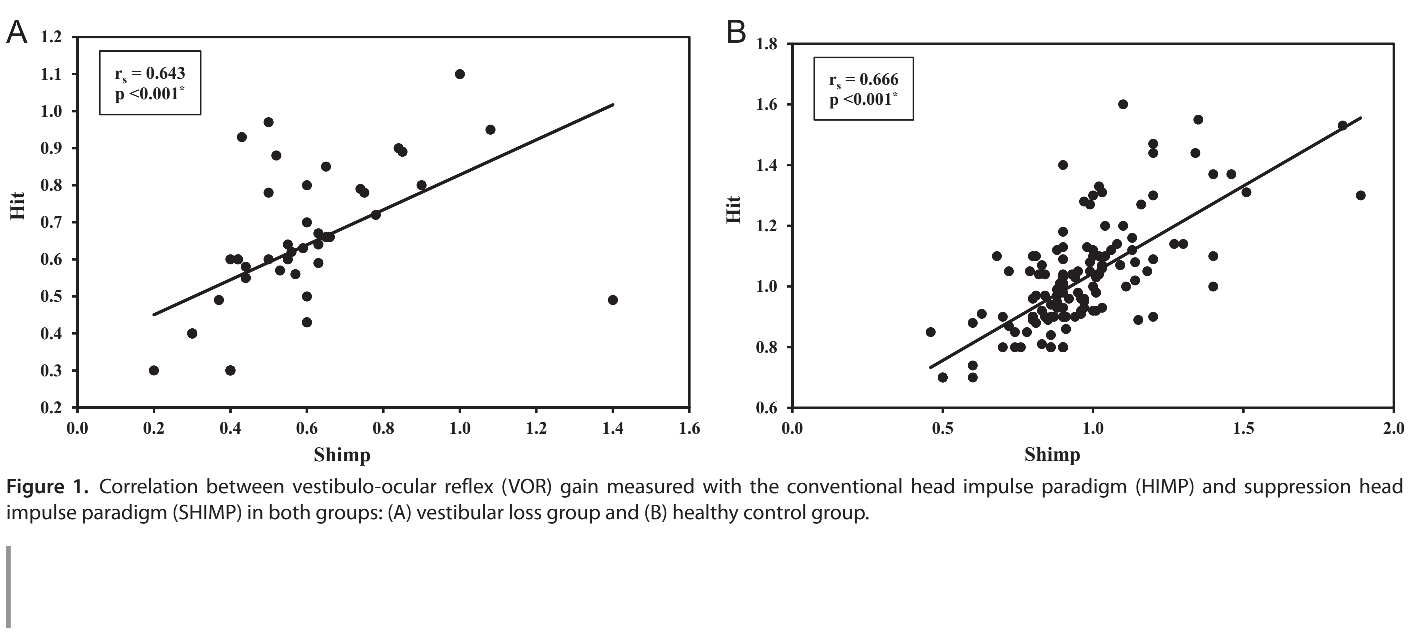

Figure 1. Correlation between vestibulo-ocular reflex (VOR) gain measured with the conventional head impulse paradigm (HIMP) and suppression head impulse paradigm (SHIMP) in both groups: (A) vestibular loss group and (B) healthy control group.

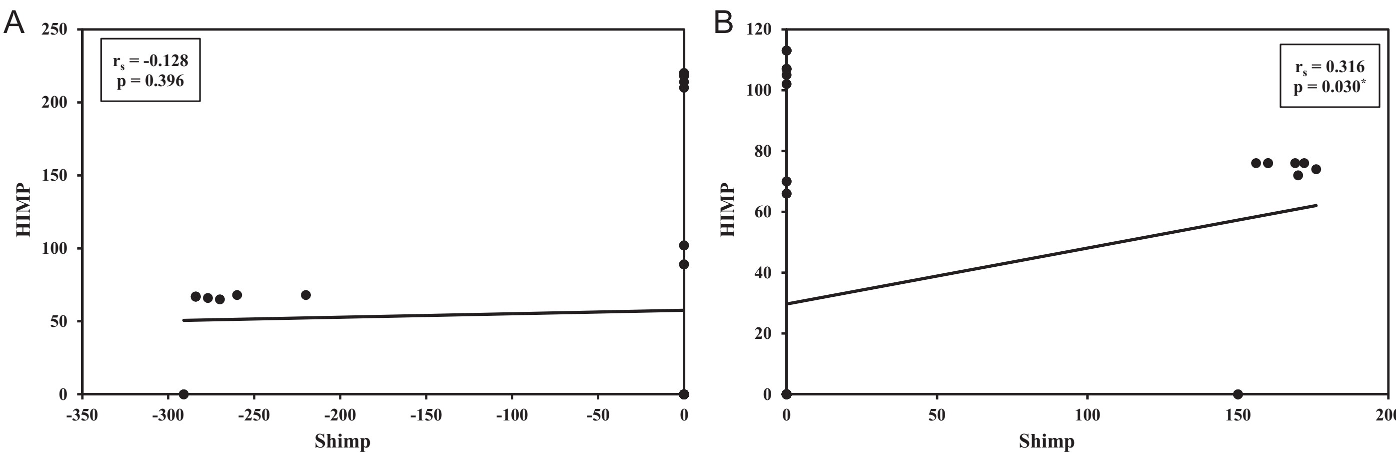

Figure 2. Correlation between amplitude (A) and latency (B) of covert saccades measured with the conventional head impulse paradigm (HIMP) and suppression head impulse paradigm (SHIMP).

and SHIMP. No correlation was found between the amplitude HIMP and SHIMP results ($r = -0.38$, $P < .09$), whereas the latency was significantly correlated ($r = -0.85$, $P < .001$). The correlations between amplitude and latency of covert and overt saccades observed with HIMP and SHIMP are shown in Figures 2 and 3.

DISCUSSION

In this study, the VOR gain value was significantly lower in both healthy controls and patients with vestibular loss when measured with the SHIMP compared to the HIMP test. This result is consistent with a previous study that documented a difference in VOR gain between measures obtained with SHIMP and HIMP. There is evidence of additional factors that contribute to lowering the VOR gain measured by SHIMP.[5] Although the underlying mechanisms causing lower VOR gain with the SHIMP test are unclear, several theories have been proposed.[6-9] Among them, the most plausible explanation is the VOR response suppression theory. Vestibulo-ocular reflex suppression is passively performed within 60-90 ms from the start of the head movement; therefore, it could be responsible for the lower VOR gain during SHIMP tests with higher head velocities.[10-12]

Our results showed that the peak head velocities were similar during SHIMP and HIMP testing, and the impulses were evaluated by the same examiner; hence, the lower VOR gains during SHIMP could not be explained by differences in the procedures. A previous study on patients with unilateral and bilateral vestibular loss suggested that this difference is an effect of either a covert saccade, the superimposed spontaneous nystagmus, or a de-saccade algorithm.[3] The present study showed a strong positive correlation between the VOR measured with the 2 paradigms (Figure 1). This result concurs with the findings of previous studies that documented a strong correlation between the VOR gain obtained with HIMP and SHIMP.[13,14]

In cases of acute vestibular weakness, SHIMP testing is superior to HIMP because the saccades detected with the SHIMP opposed the direction of spontaneous nystagmus. This characteristic reduces the error in measuring the VOR resulting from covert saccades and spontaneous nystagmus.[13,14] Hence, SHIMP testing provides more accurate information on the horizontal VOR gain than the HIMP.[4] Regarding covert saccades, no correlation was observed between the results obtained with the 2 paradigms (Figure 2); this finding could explain the lower VOR gain measured using the SHIMP in bilateral vestibular loss.[15] However, a significant difference between the VOR gain obtained with the 2 paradigms was observed in both healthy controls and patients with vestibular loss.

A previous study by Chen et al[11] revealed a greater variability with SHIMP anti-compensatory saccades than with HIMP catch-up

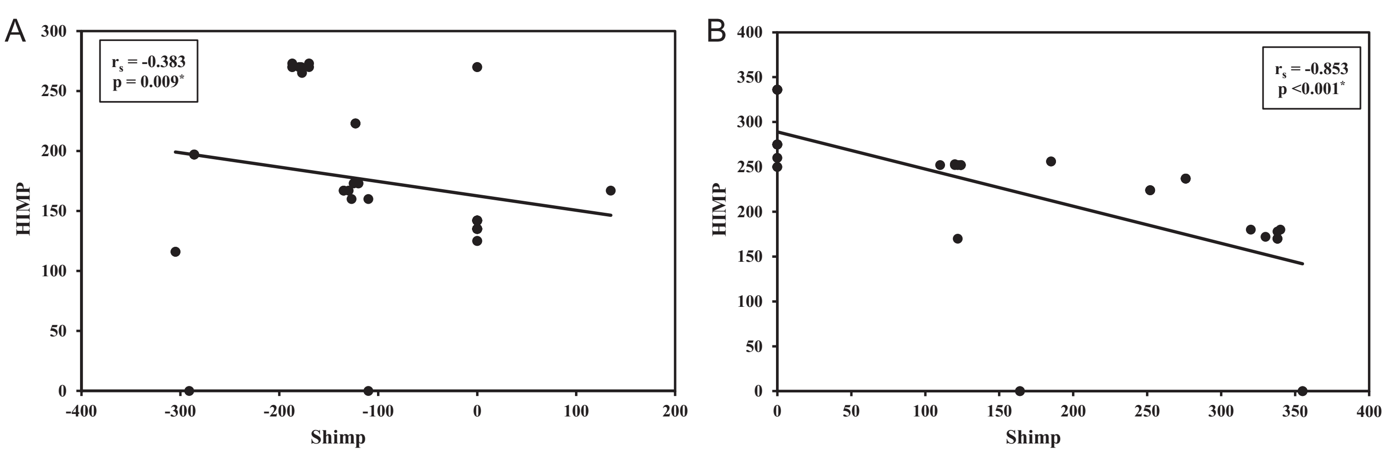

Figure 3. Correlation between amplitude (A) and latency (B) of overt saccades measured with the conventional head impulse paradigm (HIMP) and suppression head impulse paradigm (SHIMP).

saccades. This finding was explained by the difference in vestibular processing when generating saccades. For example, cortical processing could be more involved in the SHIMP anti-compensatory saccades than in the reflexive covert saccades in HIMP.[13]

We observed a strong negative correlation between the overt saccade amplitude and latency measured with the 2 paradigms (Figure 3). This observation contrasts with the findings of the study by Roh et al.[13] in which the appearance of compensatory saccades in the HIMP tests and the decrease in anti-compensatory saccades during the SHIMP tests were not correlated.

Conversely, there was no correlation between the covert saccades observed with the 2 paradigms (Figure 2). These results mean that a linear correlation exists between the appearance of the overt saccades with the HIMP HIT and the reduction of anti-compensatory saccades with the SHIMP test, implying that these methods have similar sensitivity for measuring the vestibular function. This result is consistent with the finding of a previous study that documented a strong negative correlation between HIMP and SHIMP findings in overt saccade amplitude and percentage.[14] The addition of SHIMPs paradigm declares the value of vestibulo-saccadic interaction as a tool for follow-up of the residual vestibular function in patients with VN.[15]

Since spontaneous nystagmus and overt saccades observed with the HIMP add to the complexity of measuring the VOR gain in cases of acute vestibular loss, future research on the importance of the SHIMP in measuring the VOR gain in a larger sample of such cases is necessary.

A limitation of this study was the lack of follow-up in cases with vestibular loss using both paradigms. The correlation between the parameters obtained with the 2 paradigms could help clarify the role of each type of saccades in the compensatory process.

CONCLUSION

The SHIMP and HIMP methods for HIT complement each other in evaluating vestibular function. The higher accuracy provided by the reduced covert saccades measured with the SHIMP makes this method superior to the HIMP in measuring the VOR gain, especially in patients with vestibular loss.

Ethics Committee Approval: Ethical committee approval was received from the Ethics Committee of Faculty of Medicine at Alexandria University in Egypt, 00012098 (Approval no: 00012098).

Informed Consent: Written informed consent was obtained from the patients who participated in the study.

Peer-review: Externally peer-reviewed.

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