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Correlating the Head Shake–Sensory Organizing Test With Dizziness Handicap Inventory in Compensation After Vestibular Neuritis

Hyun Woo Lim, Kyoung-Min Kim, Hyung Jin Jun, Jiwon Chang, Hak Hyun Jung, and Sung Won Chae

Department of Otolaryngology–Head and Neck Surgery, Korea University College of Medicine, Seoul, Republic of Korea

Objective: Despite complaints of dizziness, some patients with unilateral compensated vestibular weakness show normal results on Sensory Organization Test (SOT), which is being widely used for the evaluation of vestibular function compensation. The head shake-sensory organization test (HS-SOT) has been suggested to increase the sensitivity of SOT. In HS-SOT, the patient is required to shake head under Conditions 2 and 5 of traditional SOT. However, the sensitivity of HS-SOT remains unelucidated in patients with vestibular neuritis. The aim of this study was to determine the sensitivity of HS-SOT and SOT and compare them with the Dizziness Handicap Inventory (DHI) in detecting balance problems in patients with vestibular neuritis complaining of dizziness.
Setting: Tertiary referral center.
Patients: A prospective analysis was conducted on all vestibular neuritis patients between September 2009 and April 2011. Thirty-two patients with uncompensated vestibular neuritis were enrolled in this study. Patients with acute symptoms of dizziness, orthopedic problems, or any other severe underlying conditions were excluded.
Main Outcome Measures: Equilibrium and vestibular scores of SOT and equilibrium score ratios of HS-SOT and DHI were obtained from each patient after 1 week and 1, 2, and 6 months of the first attack of vestibular neuritis.
Results: HS-SOT is more correlated with the DHI than SOT by periods. One month after vestibular neuritis, the correlation between DHI and SOT, HS-SOT Conditions 2 and 5 were −0.301, −0.385, and −0.625, respectively. Six months after vestibular neuritis, the correlation between DHI and SOT, and HS-SOT Conditions 2 and 5 were −0.053, −0.337, and −0.394, respectively.
Conclusion: HS-SOT was more sensitive than SOT during the compensation of vestibular neuritis. Specifically, during the compensation of vestibular neuritis, HS-SOT Condition 5 was more correlated with DHI than HS-SOT Condition 2. The results suggest that HS-SOT provides more useful measures for the evaluation of vestibular compensation in vestibular neuritis. **Key Words:** Compensation—Dizziness Handicap Inventory—Head Shake–Sensory Organization Test—Vestibular neuritis.
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The Sensory Organization Test (SOT) is a category of computerized dynamic posturography. Whereas other tests for dizziness and balance, such as electronystagmography, caloric test, and rotatory chair test, evaluate only the vestibulo-ocular reflex, SOT provides more integrated measures for balance (1–3). SOT is an important test to monitor improvement in postural stability and vestibular rehabilitation. However, the reported sensitivity of SOT varies from 20% to 80% (3,4). This wide variation in sensitivity has been considered an obstacle to its validity. In addition, the SOT is not sensitive in the detection of abnormalities in subjects with vestibular disorders who are well compensated, such as individuals with unilateral vestibular disorders (3). Some patients with unilateral compensated vestibular weakness showed normal SOTs despite experiencing dizziness (5).

Because of these limitations, there exist modifications of the standard SOT to improve its sensitivity, such as head tilting during SOT. Head shake–sensory organization test (HS-SOT) is another modification of SOT. The difference between SOT and HS-SOT is that in HS-SOT, the subject is required to shake the head during the respective SOT condition with velocity measured by a rate sensor attached to the head. Compared with standard SOT, HS-SOTs are thought to have higher sensitivity in detecting balance problems in patients who score within the normal limits (6). HS-SOT also is expected to evaluate patients in the compensated period with higher sensitivity than

Address correspondence and reprint requests to Sung Won Chae, M.D., Ph.D., Department of Otolaryngology–Head and Neck Surgery, Guro Hospital, Korea University College of Medicine, 80 Guro-dong, Guro-gu, Seoul 152-703, Republic of Korea; E-mail: schae@kumc.or.kr
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the standard method. However, no study has evaluated the effectiveness of HS-SOT longitudinally in compensated patients who experience dizziness.

The aims of this study were to determine the effectiveness of HS-SOT among compensated vestibular neuritis patients by comparing the outcomes of HS-SOT and SOT with that of the Dizziness Handicap Inventory (DHI) (7).

MATERIALS AND METHODS

Subjects

Thirty-two consecutive patients with acute vestibular neuritis were recruited at the dizziness clinic of the Korea University Guro Hospital between September 2009 and April 2011. The inclusion criteria were acute vertigo with spontaneous nystagmus, no hearing loss, and no additional neurologic signs or symptoms. The diagnosis of vestibular neuritis was confirmed when the caloric test showed more than 25% of canal paresis on the affected side. All patients were evaluated by the positioning test, positional test, head shake test, caloric test, SOT, HS-SOT, DHI, and pure-tone audiometry. All patients were initially evaluated within 3 days of symptom onset. They were scheduled for reevaluation at 1 week and 1, 2, and 6 months after the first evaluation with SOT, HS-SOT, and DHI. All patients were allowed vestibular suppressants for the acute phase and underwent vestibular rehabilitation with an identical protocol as soon as possible. All participants gave informed consent before study entry. This study was approved by the institutional review board of the Korea University Guro Hospital.

Dizziness Handicap Inventory

The Dizziness Handicap Inventory (DHI) is consisted of a 25-item, validated, self-reported questionnaire. The DHI is to be responded in 3 steps: 9 questions on function, 7 on physical, and 9 questions on emotional issues, with 100 points to score in total. Each question is given 3 options to answer: ''No'' (0 points), ''Sometimes'' (2 points), or ''Yes'' (4 points).

Balance Test

The balance tests were consisted of the SOT and HS-SOT. The Equitest Balance Master (Neurocom International Inc., Portland, OR, USA) was used in this study. For HS-SOT, patients were instructed to shake their head only along the yaw (horizontal) axis (Fig. 1). Horizontal rotatory head motion was performed through an arc of approximately 30 degrees to both sides, with an auditory beep provided with the tracking system at 1 Hz with the neck flexed for approximately 30 degrees. This procedure was performed for both SOT Conditions 2 and 5. Each condition was measured 3 times, and the average score was calculated. Composite equilibrium scores, vestibular scores, and equilibrium score ratios for HS-SOT/SOT at each condition was acquired.

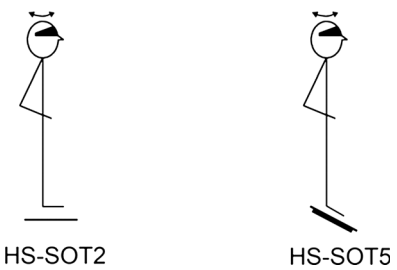

FIG. 1. Schematic diagram of HS-SOT conditions. SOT consists of 6 conditions. In each condition, the patient is required to open or close the eyes, face a stationary or a moving visual surround, and stand on a stable or a moving platform. In HS-SOT, the patient is required to shake the head horizontally at a regular speed of approximately 1 Hz in Conditions 2 (closed eyes) and 5 (closed eyes and moving platform).

Statistical Analysis

The correlation coefficient between DHI and the equilibrium score ratios of Conditions 2 and 5 in the HS-SOT, the composite equilibrium, and the vestibular scores of the SOT were calculated according to periods. A p value of less than 0.05 ($p < 0.05$) was considered a statistically significant difference. All data are expressed as means ± standard deviation. All statistical analyses were performed using SAS version 9.1 (SAS Institute Inc., Cary, NC, USA).

RESULTS

Thirty-two patients, including 13 men and 19 women, with acute vestibular neuritis were enrolled in this study. The mean age was 55.6 years. The mean canal paresis determined by bithermal air caloric test was 56.3. The initial score of DHI and the composite score of SOT were 43.3 and 61.6, respectively. The initial equilibrium score ratio of HS-SOT Conditions 2 and 5 were 0.23 and 0.01, respectively. At 1 week and 1, 2, and 6 months after the onset of vestibular neuritis, the mean DHI gradually decreased to 33.6, 19.1, 12.2, and 8.6, respectively. Meanwhile, the mean composite score of SOT was 71.8, 79.1, 81.4, and 83.1 at respectively 1 week and 1, 2, and 6 months. The equilibrium score ratios of HS-SOT Condition 2 were 0.30, 0.46, 0.54, and 0.56 at 1 week and 1, 2, and 6 months, respectively, compared with that of Condition 5 of 0.10, 0.30, 0.38, and 0.49 at the same time points (Fig. 2).

DHI and SOT

One week and 1, 2, and 6 months after the onset of vestibular neuritis, the correlation coefficients between DHI and composite scores of SOT were −0.679, −0.301, −0.332, and −0.053, respectively (Table 1). Initially, the composite score of SOT was more correlated with the DHI than the equilibrium score ratios of HS-SOT 2 and 5. However, correlation between the composite scores of SOT and DHI was statistically significant only in the acute stage. One month after the onset of vestibular neuritis, correlation between the composite score of SOT and DHI was not statistically significant. The composite scores of SOT were not significantly correlated with DHI 1 month after the onset of vestibular neuritis.

DHI and HS-SOT

At the first visit, the correlation coefficient between HS-SOT Condition 2 and DHI was −0.559. One week and 1, 2, and 6 months after the onset of vestibular neuritis, the equilibrium score ratios of HS-SOT Condition 2 became −0.695, −0.385, −0.401, and −0.337, respectively. After 6 months of vestibular neuritis, correlation between HS-SOT Condition 2 and DHI was not statistically significant (Table 1). The initial correlation coefficient between the equilibrium score ratio of HS-SOT Condition 5 and DHI

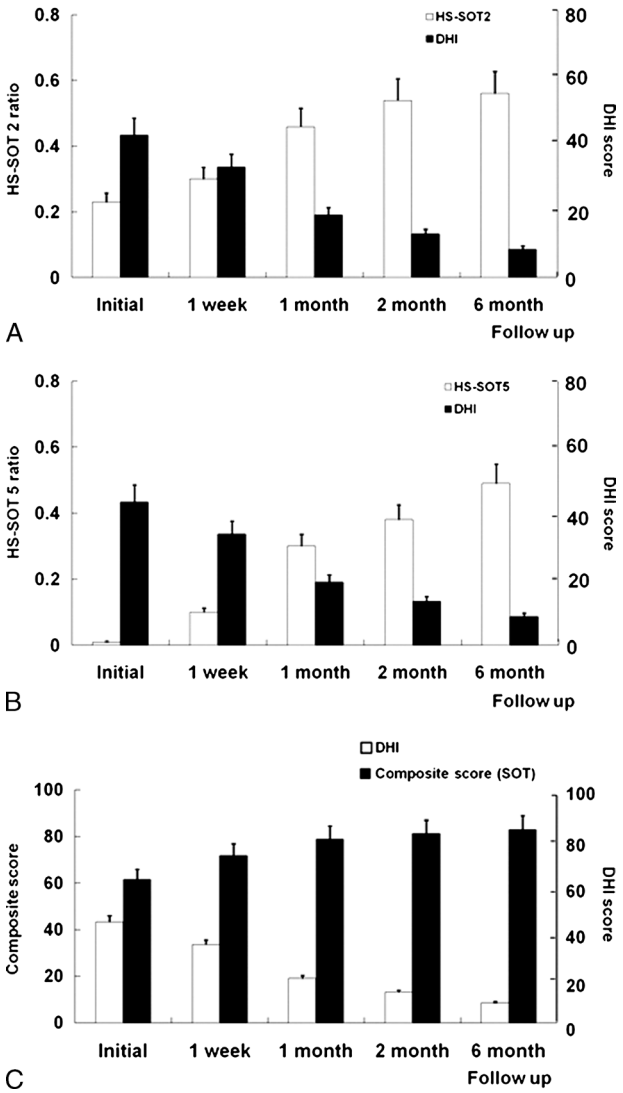

FIG. 2. Correlation of HS-SOT and SOT compared with DHI in the compensation period of vestibular neuritis. Correlation between HS-SOT Condition 2 and DHI is statistically significant from the beginning to 2 months after vestibular neuritis (*A*). Through the examination, HS-SOT Condition 5 was well correlated with the DHI (*B*). The composite score of SOT was only correlated with DHI in the acute stage of vestibular neuritis (*C*). The error bars indicate standard deviations.

was -0.402. One week and 1, 2, and 6 months after the onset of vestibular neuritis, the equilibrium score ratios of HS-SOT Condition 2 became −0.539, −0.625, −0.461, and −0.394, respectively. Throughout the period, the equilibrium score ratios of HS-SOT Condition 5 remained significantly correlated with DHI (Table 1).

DISCUSSION

Vestibular neuritis is characterized by acute onset of vertigo associated with nausea, vomiting, and generalized imbalance. The acute vertiginous symptoms often are severe and can last from a few hours to several days. Once the acute phase of vestibular neuritis has passed, symptoms gradually improve because of central compensation. In the intervening period, treatment efforts are focused on improving central compensation through vestibular rehabilitation, for which a lot of methods have been developed for clinical use (8). In addition, evaluation of the compensated patients also is important. Traditional balance and vestibular function tests, such as the bithermal caloric test and rotatory chair test, are useful diagnostic tools for acute dizziness. However, outcomes of these tests does not always show to correlate with symptoms experienced by patients with well-compensated unilateral vestibulopathy (9,10). Among various tests, such as the head shaking nystagmus, head thrust test, caloric test, and vibration-induced nystagmus, and dynamic vestibular balance tests may provide more useful information for the underlying vestibulopathy, particularly in the compensated phase (11). In this respect, HS-SOT is an effective method for the evaluation of compensated vestibular neuritis.

In this study, we evaluated the effectiveness of HS-SOT by comparing it with the DHI. The DHI can be used as a tool to evaluate reduction in quality of life caused by dizziness in patients with acute vestibulopathy. From a clinical point of view, the DHI is an instrument to evaluate, during the follow-up period, the efficacy of rehabilitation, medications, and/or surgery (12). Patients usually complain of minor symptoms in the compensated phase. As such, patient's self-assessed problems appeared significant, and this is another reason to adopt DHI in this study.

HS-SOT is a modification of SOT. HS-SOT provides additional challenge to the sensory organizational mechanism and quantifies problems in patients with subtle problems who otherwise perform within the normal limits on the standard SOT. The HS-SOT is a useful adjunct in symptomatic patients with normal results on standard SOT. Dynamic movement of the head such as head shaking with eyes closed (Condition 2 or 5) can generate vestibular imbalance and reduce central compensation.

TABLE 1. *Correlation coefficients between Dizziness Handicap Inventory and outcomes of balance tests with respect to period of vestibular neuritis*

	Initial	1 Wk	1 Mo	2 Mo	6 Mo
SOT (Composite score)	−0.787*	−0.679*	−0.301	−0.332	−0.053
Equilibrium score ratio (HS-SOT Condition 2)	−0.559*	−0.695*	−0.385*	−0.401*	−0.337
Equilibrium score ratio (HS-SOT Condition 5)	−0.402*	−0.539*	−0.625*	−0.461*	−0.394*

DHI indicates Dizziness Handicap Inventory; HS-SOT, Head Shake–Sensory Organization Test; SOT, Sensory Organization Test.
*$p < 0.05$.

HS-SOTs can evaluate the function of dizzy patients more precisely even when they are in the course of compensation. Head movements challenge the system by generating vestibular stimuli in addition to that generated by the patient's sway. To maintain balance in the absence of alternative visual inputs (Condition 2 or 5) while moving the head, the brain must differentiate the sway and head shake stimuli. Degradations in the sensitivity and accuracy of the vestibular receptors can interfere with the process of signal differentiation and reduce stability during head shaking. The vestibular system is composed of multiple, direction-specific sense organs. Degradations may be axis specific, creating instability when head movements occur about the involved axis.

In this study, patients after experiencing 1 month of vestibular neuritis achieved normal SOT scores. The change in composite score ratio of SOT was not significantly correlated with DHI from 1 month to 6 months among vestibular neuritis patients. This result demonstrated that SOT alone does not elucidate the subtle changes of compensation in vestibular neuritis patients. On the other hand, the equilibrium score of HS-SOT showed reliable correlation with the DHI despite progression of compensation. This result demonstrated that HS-SOT is capable of detecting discomfort in patients more sensitively. Interestingly, the result of SOT showed more correlation than HS-SOT with the DHI in the acute stage, and this result is consistent with that reported previously.

In this study, we only evaluated the horizontal axis of HS-SOT because it is more significantly affected than pitch or roll axes on the equilibrium score (13), and the horizontal axis is more convenient to evaluate than other axis.

The results of this study correspond well with those of an earlier study, which reported that functional balance tests based on walking performance correlated better with DHI scores compared with static balance measures (14). When the patient's complaints are taken into consideration, dynamic performance or functional problems is more important than static performance in the compensation phase after vestibular neuritis. HS-SOTs remove visual input in the control of postural stability. Visual simulations showed the impact on frequency range of 0.03 to 0.1 Hz, and the main part of reduced visual input is compensated by the vestibular system (15). As such, HS-SOT is capable of evaluating dynamic vestibular function more precisely by removing visual input.

CONCLUSION

The HS-SOT is a modification of SOT and is a useful tool to evaluate vestibular neuritis patients in the compensation period. Condition 5 of HS-SOT is more correlated than Condition 2 of HS-SOT with the DHI in the compensated period of patients with vestibular neuritis.

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