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Original Research

Comparision of Video Head Impulse Test Findings Before and After Therapy Maneuvers in Individuals with Benign Paroxysmal Positional Vertigo

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Abstract

Objective: To investigate the significance of vHIT (Video Head Impulse Test) in determining the efficacy of therapeutic maneuvers in individuals with posterior semicircular canal (SCC) BPPV.
Materials and Methods: The study included 25 patients with posterior SCC BPPV (Study Group), 30 healthy individuals (Control Group). All individuals underwent otorhinolaryngologic examination, audiological evaluation, videonystagmography, vHIT and completed Dizziness Handicap Inventory (DHI) and Visual Analogue Scale (VAS). Modified Epley Maneuver was performed 3 times at an interval of 3 days. The vHIT, DHI and VAS were re-administered to these individuals 1 week after improvement was detected in positional nystagmus.
Results: There was no significant difference between the study and control groups in terms of vHIT gains for all bilateral SCCs before therapeutic maneuver ($p>0.05$). In the study group, there was no significant difference between vHIT gains of all bilateral SSCs before and after therapeutic maneuvers ($p>0.05$). No asymmetry or refixation saccades (overt and covert) were observed in any of the individuals in both groups during all measurements. Compared to before therapeutic maneuvers, there was a significant decrease in dizziness-related disability level assessed by DHI and intensity of dizziness assessed by VAS in the study group after the improvement ($p<0.001$).
Conclusion: It was found that vHIT was not a diagnostic test in BPPV and in terms of evaluating the efficacy of therapeutic maneuvers. Subjective evaluations determining the intensity of dizziness and level of dizziness-related disability in BPPV provided supportive information in diagnosis and in determining the efficacy of therapeutic maneuvers.

Keywords: *Dizziness, Benign Paroxysmal Positional Vertigo (BPPV), Video Head Impulse Test (vHIT), Vertigo*

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Introduction

In benign paroxysmal positional vertigo (BPPV), the most common peripheral vestibular disorder, the attacks of vertigo last less than a minute and generally, patients are completely asymptomatic between attacks (De Waal, 2004). Although BPPV symptoms may resolve spontaneously, the symptoms can last for days, weeks, months or years (Hornibrook, 2011).

In the pathophysiology of BPPV, Schucknecht explained the theory of "cupulolithiasis" for the first time in 1969 (Schuknecht, 1969). According to the theory, otolith debris adheres to the cupula, making the specific gravity of the cupula sensitive to gravity, therefore nystagmus occurs in changes in the head position. In 1979, Hall proposed the theory of "canalolitiasis". According to this theory, otolith debris separating from the macula of utricle moves freely in the semicircular canal (SCC) and causes deflection in the endolymph flow during position changes, resulting in vertigo and nystagmus (Hall et al., 1979). The theory of canalolitiasis was supported by intraoperative observation of free-floating otoconium in the endolymph inside the posterior SCC (Parnes & Mcclure, 1992). This theory has formed the theoretical basis for the canalith repositioning maneuver used to treat BPPV (Epley, 1992). Various therapeutic maneuvers have been developed for benign paroxysmal positional vertigo. The most common therapeutic maneuvers for posterior SCC BPPV are the Epley Maneuver , Semont Maneuver (Semont et al., 1988).

In vestibular disorders, saccades occur during or after head movements (Weber et al., 2008). Refluxation saccades are thought to show a decrease in vestibulo-ocular reflex (VOR) gains. Free-floating degenerative debris in the posterior SCC causes abnormal stimulation in the endolymphatic flow, leading to deterioration in gaze stabilization (Chen et al., 2012). It has been reported that VOR may be helpful in the diagnosis of BPPV due to peripheral abnormality and vertigo and nystagmus occurring by certain head movements in individuals with BPPV (Ozgirgin & Tarhan, 2008). Video Head Impulse Test (vHIT) can effectively diagnose VOR deficits caused by peripheral vestibular disorder (Jorns-Häderli et al., 2007). In this test, VOR gain values and refixation saccades can be quantitatively analyzed. It has been found that vHIT may be significant in the diagnosis of vestibular disorders, particularly associated with anterior and posterior SCCs (Mangabeira Albernaz & Zuma e Maia, 2014).

The aim of this study is to investigate the role of vHIT in determining the efficacy of therapeutic maneuvers in individuals with posterior SCC BPPV. According to our

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hypothesis, there is a difference between vHIT findings obtained before and after therapeutic maneuvers in individuals with posterior SCC BPPV.

Materials and methods

The study was conducted in a local university, Medical Center, Department of Otorhinolaryngology. Ethics Committee approval (Ankara Yıldırım Beyazıt University Ethics Committee 23.02.2018-24) was obtained. All individuals underwent otorhinolaryngologic examination, and detailed anamnesis was obtained. The sample group of this study was determined by power analysis. According to the calculation made using the G power 3.1 program; When the effect size was predicted as 0.625 in order to compare the control and patient groups with 95% confidence level and 80% power, the minimum sample size required to be included in the study per group was calculated as 25 for the patient group and 30 for the normal group. The study group included 25 individuals (15 females, 10 males; mean age 43.20 ± 12.96 years) who were diagnosed with posterior SCC BPPV by positional tests, had BPPV attack for the first time and did not have multi-canal or bilateral involvement. The control group included 30 individuals (17 females, 13 males; mean age 42.53 ± 12.53 years) who had no vertigo and nystagmus findings in positional tests and had normal vHIT findings. 20 head thrusts were performed in each canal plane. An asymmetry value of less than 7%, an approximate gain average of 0.96 and the absence of refixation saccades (overt or covert) were determined as normal vHIT findings. The study inclusion criteria for all individuals were as follows: 1) Bilateral pure tone average (500-4000 Hz) not greater than 20 dB, 2) Obtaining bilateral Type A tympanogram and normal ipsilateral and contralateral acoustic reflexes in the immitancemetric evaluation, 3) The absence of spontaneous nystagmus, head-shaking nystagmus in the videonystagmography (VNG), normal gaze test and oculomotor test findings, 4) The absence of otologic, neurological and systemic diseases that cannot be controlled by medication, 5) The absence of previous ear surgery and vertigo attacks, 6) Scoring 24 or above from the Mini-Mental Test, 7) Having normal vision using the rate of 0.7 with the Snellen chart, 8) Volunteering, 9) The absence of cervical problem.

Mini Mental Test

In the Mini Mental Test consisting of 11 items and five main sections including recall, registration, language, attention, and calculation, the evaluation was made over 30 points. The individuals who scored 24 points and above were included in the study (Anthony et al., 1982).

Audiological Evaluation

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The pure tone air-conduction thresholds of the individuals included in the study were determined in the frequency range of 125-6000 Hz (right/left ear) using the Interacoustics AC40 Clinical Audiometer and TDH 39 P Telephonics (supro-aural) earphones in the quiet booths of Industrial Acoustics Company (IAC) Inc. Bone-conduction thresholds were determined in the frequency range of 500-4000 Hz using the Radio ear B71 bone vibrator. All individuals included in the study were sought to meet the criterion of a pure tone average of less than 20 dB (in the frequency range of 500-4000Hz). Using the Interacoustics AT235H device, the tympanometric measurements of the patients were performed with a 226 Hz probe tone, and their ipsilateral and contralateral acoustic reflex thresholds were determined in the frequency range of bilateral 500-4000 Hz. The individuals with type A tympanogram and normal ipsilateral and contralateral acoustic reflexes were included in the study.

Videonystagmography (VNG)

The Micromedical Technologies INC device and VisualEyes 4 channel software were used in the videonystagmographic evaluation. The gaze test, saccade test, pursuit test, optokinetic test, spontaneous nystagmus test and positional tests were administered to all individuals. During the Dix Hallpike maneuver, the patients were placed in the sitting position with the head extended to 30º after the head was rotated 45º to one side, and the presence of positional nystagmus was evaluated. The same maneuver was performed for the other side. The presence of vertical, torsional nystagmus and vertigo towards the rotated side of the head was determined as the diagnostic criteria for posterior SCC BPPV (Von Brevern et al., 2015).

Video Head Impulse Test (vHIT)

vHIT was performed using the EyeSeeCam vHIT (Interacoustics, A/S DK-5610, Assens, Denmark) device and OtoAccessTM computer software. All patients were seated in a chair at a 1.5-meter distance from the point on the wall. The eye was adjusted to the center of the video screen by means of the movable camera on the glasses. After head and eye calibration was done, the individual was asked to look straight at the object on the opposite wall in the lateral SCC stimulation and the head was bent at 30° forward. The clinician stood directly behind the individual. By grasping the head with two hands, head impulses were applied by the clinician at small angles of 15-20 degrees to the left and right, which the individual could not predict.

For stimulation in vertical SCCs, the test was started when the individual sat

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looking straight ahead. For right anterior and left posterior (RALP) SCCs, the head was stimulated diagonally in the right anterior and left posterior plane. Forward and backward (by placing in the primary line in between) impulse was applied to the head at angles of 15-20 degrees. In order to stimulate left anterior right posterior (LARP) SCCs, 15-20 degree backward and forward impulse was applied to the head in the left anterior and right posterior plane when the head was in the midline.

At least 10 impulses with the correct velocity and amplitude were performed (peak head velocity in the first 80 °/s and 150 ms with the head velocity greater than 1000 °/s when the movement of the head started), and the results were recorded.

Dizziness Handicap Inventory (DHI)

DHI was administered to all individuals with BPPV before therapeutic maneuver. In the inventory consisting of a total of 25 questions, "yes" answer was scored as 4 points, "sometimes" as 2 points and "no" answer was scored as 0 points. Physical, functional and emotional sub-score that may be caused by dizziness and total score were recorded. In the inventory with a total score of 100, the maximum score for physical disability is 28, the minimum score is 0; the maximum score for functional and emotional disability is 36, the minimum score is 0 (Karapolat et al., 2010).

Visual Analog Scale (VAS)

VAS was administered to all individuals with BPPV before therapeutic maneuver. On a 10-cm line drawn on a paper, the starting point "0" defined absence of vertigo, the end point "10" defined very severe vertigo. The patient was asked to mark on the line the point that best represents his/her own vertigo. The distance of the marked point was measured in cm (Wewers & Lowe, 1990).

Modified Epley Maneuver

The Modified Epley maneuver (Canalith Reposition Maneuver) was applied to the individuals with posterior SCC BPPV 3 times at 3-day intervals. The patient was seated on the examination table and his/her head was rotated 45 degrees towards the affected ear. The patient was quickly brought to the supine position with the neck extended at 30 degrees, and it was waited for 2 minutes or until nystagmus recovered. The head was rotated 90 degrees towards the unaffected ear while maintaining the 30-degree extension position of the neck. It was waited for 2 minutes or until nystagmus recovered. The patient was placed in the side-lying position and the patient's face was placed parallel to the ground by rotating the head

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downwards. It was waited for 2 minutes or until nystagmus recovered, and finally, the patient was placed in the sitting position (Solomon, 2000).

Post-Therapeutic Maneuver Evaluation

The vHIT, DHI and VAS evaluations were repeated after 1 week in all individuals with posterior SCC BPPV who did not have nystagmus and had improved symptoms in the positional tests conducted with VNG for follow-up.

Statistical Analysis

The data were analyzed by using the IBM SPSS V23. Normality was analyzed by the Shapiro-Wilk test. The independent sample t-test was used for intergroup comparison of normally distributed data, and the paired t-test for intragroup comparison. The intergroup comparison of non-normally distributed data was performed using the Mann Whitney U test, and the intragroup comparison with the Wilcoxon test. The chi-square test was used to compare qualitative data. Normally distributed data were expressed as mean ± standard deviation, while non-normally distributed data were expressed as median (min-max) and qualitative data were presented as frequency (percentage). The level of significance was accepted as $p<0.05$.

Results

In the study group, 14 (56%) patients had right posterior SCC BPPV, and 11 patients (44%) had left posterior SCC BPPV. In all patients, nystagmus and vertigo were improved by therapeutic maneuvers. Improvement in nystagmus and symptoms was achieved with 1 maneuver in 15 patients (60%) who received the modified Epley Maneuver, with 2 maneuvers in 6 patients (24%), and with 3 maneuvers in 4 patients (16%).

Table 1: Comparison of the pre-treatment vHIT gain values of the study and control groups.

Gain	Study Group (Mean±SD)	Control Group (Mean±SD)	p
Right Anterior SCC	1,07 ± 0,07	1,04 ± 0,09	0,22*
Left Anterior SCC	0,99 ± 0,09	1,03 ± 0,09	0,09*
Right Lateral SCC	0,97 ± 0,09	0,96 ± 0,05	0,48*
Left Lateral SCC	0,97 ± 0,10	1,00 ± 0,08	0,24*
	Median (min-max)	**Median (min-max)**	
Right Posterior SCC	0,91 (0,71 - 1,15)	0,96 (0,83 - 1,2)	0,19**
Left Posterior SCC	0,98 (0,85 - 1,13)	0,96 (0,74 - 1,15)	0,56**

SCC: Semicircular canal *: *Mann Whitney U test* **:*Independent t test*

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There was no statistically significant difference between study and control groups in terms of vHIT gain values for all SCCs before the treatment (p>0.05) (Table 1).

Table 2: Comparison of vHIT gain values before and after therapy maneuvers in the study group

Gain	**Median (min-max)**	**p**
Pre-treatment Right Lateral SCC	1,01 (0,75 - 1,12)	
Post-treatment Right Lateral SCC	1.00 (0,77 - 1,09)	0,65*
Pre-treatment Right Posterior SCC	0,91 (0,71 - 1,15)	
Post-treatment Right Posterior SCC	0,96 (0,65 - 1,09)	0,06*
Pre-treatment Left Posterior SCC	0,98 (0,85 – 1,13)	
Post-treatment Left Posterior SCC	0,97 (0,75 – 1,13)	0,05*
	(Mean±SD)	**p**
Pre-treatment Left Lateral SCC	0,97 ± 0,10	
Post-treatment Left Lateral SCC	0,99 ± 0,09	0,16**
Pre-treatment Right Anterior SCC	1,07 ± 0,07	
Post-treatment Right Anterior SCC	1,05 ± 0,07	0,56**
Pre-treatment Left Anterior SCC	0,99 ± 0,09	
Post-treatment Left Anterior SCC	1,00 ± 0,11	0,08**

vHIT: Video Head Impulse Test **: Wilcoxon test* ***:Paired sample t test*

In the study group, there was no statistically significant difference between vHIT gain values for all SCCs before and after therapeutic maneuvers (p>0.05) (Table 2). No asymmetry or refixation saccades (overt and covert) were observed during the vHIT in any of the individuals in both groups.

Table 3: Comparison of DHI results before and after therapy maneuvers in the study group

	Median (min-max)	**p**
DHI		
Pre-treatment Emotional	10 (0-28)	
Post-treatment Emotional	4 (0-18)	**<0,001***
Pre-treatment Functional	20 (8-36)	
Post-treatment Functional	6 (2-22)	**<0,001***
Pre-treatment Physical	14 (2-20)	
Post-treatment Physical	6 (0-12)	**<0,001***
Pre-treatment Total	42 (12-78)	
Post-treatment Total	16 (4-52)	
VAS		
Pre-treatment	6 (5-10)	
Post-treatment	3 (0-6)	**<0,001***

vHIT: Video Head Impulse Test *VAS: Visual Analog Scale* **: Wilcoxon test*

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In the study group, there was a statistically significant difference between the values obtained before therapeutic maneuvers and after improvement in terms of emotional, functional, physical sub-scores and total scores of the DHI and VAS scores ($p<0.001$) (Table 3).

Discussion and Conclusion

In our study, there was no difference between the study and control groups before therapeutic maneuvers in terms of vHIT gain values for all six SCCs. No asymmetry or refixation saccades (overt and covert) were observed in any SCC in the study and control groups during the vHIT. In the study group, there was no significant difference between the vHIT gain values for all SCCs before and after therapeutic maneuvers. In the literature, there were a limited number of studies (Çınar et al., 2018; Eza-Nuñez et al., 2014; Fallahnezhad et al., 2017; Guan et al., 2017; Ozgirgin & Tarhan, 2008) evaluating VOR with vHIT in individuals with BPPV, and the results of these studies differ from each other. There were only two studies (Çınar et al., 2018; Ozgirgin & Tarhan, 2008) in the literature evaluating the effect of therapeutic maneuvers on VOR.

In a study by Fallahnezhad et al. (Fallahnezhad et al., 2017), the VOR gain for six SCCs, gain asymmetry and refixation saccade presence were evaluated with vHIT in patients with posterior SCC BPPV. This study included 29 individuals with unilateral posterior SCC BPPV who had normal oculographic and caloric test results. Abnormal posterior SCC VOR gain was found in the ipsilateral ear in 16 (55.17%) patients. VOR gains were found to be within normal limits in both lateral SCCs, and anterior SCC VOR gains were found to be lower than normal. Our result, similar to the result of Fallahnezhad et al. (Fallahnezhad et al., 2017), is that the lateral SCC VOR gains of the individuals with posterior SCC BPPV were within normal limits and no refixation saccade was detected. Abnormal gain obtained in the posterior and anterior SCCs in the study by Fallahnezhad et al. (Fallahnezhad et al., 2017) differs from our study result. Free-floating otoconium in the SCCs due to endolymphatic movement cause abnormal crystal stimulation with the effect of the hydrodynamic piston, which disrupts VOR and gaze stabilization (Chen et al., 2012). The presence of severe vestibular damage can cause corrective saccades. In addition, disorders seen with BPPV also contribute to saccade formation (Eza-Nuñez et al., 2014). The inclusion of the patients without additional vestibular pathologies and recurrent attacks in our study may have been effective in obtaining normal VOR gain. The inhibitory effect

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of saccules caused by SCCs on VOR leads to VOR deficits. Severe saccular dysfunction can be observed in recurrent BPPV (Gacek, 2013). Due to the fact that the individuals who had a BPPV attack for the first time were included in our study, the potential inhibitory effect of the saccule on VOR and VOR deficit may not have occurred. More comprehensive information on this subject can be obtained with studies to evaluate the saccular function.

Similar to our study, Cinar et al. (Çınar et al., 2018) methodologically compared vHIT results before and after therapeutic maneuvers in 24 patients with isolated posterior SCC BPPV. Similar to our results, they did not find a significant difference between the study and control groups in terms of vHIT results (VOR gain, gain asymmetry, corrective saccades) obtained before the therapy. They also did not find any significant difference between vHIT results before and after therapeutic maneuvers. The researchers stated that vHIT did not additionally contribute to diagnosis and treatment for posterior SCC BPPV. In the study by Ozgirgin et al. (Ozgirgin & Tarhan, 2008), VOR was evaluated with the head autorotation test in 20 patients diagnosed with posterior SCC BPPV before and after therapeutic maneuver. For lateral rotation tests, there was no significant difference between before and after the Epley Maneuver in terms of VOR averages gain values. Phase values, one of the evaluation parameters in the head autorotation test, were within normal limits in lateral and vertical rotation tests and were preserved in the same way after the Epley maneuver. While Ozgirgin and Tarhan (Ozgirgin & Tarhan, 2008) used the head autorotation test to evaluate the high-frequency VOR that occurs in daily life activities, we used vHIT in our study. In our study, similar to the study results of Ozgirgin and Tarhan (Ozgirgin & Tarhan, 2008), there was no difference between VOR gains obtained before and after therapeutic maneuvers in patients with posterior SCC BPPV. This result does not support our hypothesis that "there is a difference between vHIT results obtained before and after therapeutic maneuver in individuals with BPPV". The normal vHIT results in individuals with posterior BPPV before therapeutic maneuvers may be effective in no difference after the therapy. Although VHIT is an effective and complementary test in evaluating VOR and peripheral vestibular function (Blödow et al., 2014), the results we obtained in our study showed that vHIT was not a diagnostic test in BPPV and in terms of evaluating the efficacy of therapeutic maneuvers.

In our study, the benefit obtained with maneuver in individuals with posterior SCC BPPV was demonstrated by only subjective evaluations (DHI and VAS). After the modified Epley maneuver, there was a significant improvement in the physical, emotional and functional subtest scores of DHI,

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total DHI score and VAS scores of the individuals with posterior SCC BPPV. The patients stated that the limitations in their daily living activities ended after the maneuvers and that they could continue the activities they could do before BPPV (going to work, doing housework, doing sports, etc.). DHI and VAS results also support an increase in the quality of life after maneuver in patients.

The fact that the efficacy of the therapy maneuvers is supported by subjective evaluations show similarities with the literature (André et al., 2010; Khatri et al., 2005). Andre et al. (André et al., 2010) achieved a significant improvement in DHI scores of individuals with BPPV after therapeutic maneuver. Kollen et al. (Kollén et al., 2006) found that individuals with BPPV had a significant improvement in the vertigo evaluated by VAS after therapeutic maneuvers. Recurrent and chronic BPPV can be adequately evaluated by using current vertigo questionnaires such as the DHI (Jacobson & Newman, 1990). In the evaluation of treated BPPV, which can be followed by short-term residual dizziness, an alternative questionnaire/scale may be needed that can differentiate vertigo from dizziness, such as VAS (Toupet et al., 2011). We were unable to find any effect on VOR in individuals with posterior SCC involvement who had BPPV attacks for the first time. We did not obtain any change in vHIT results after the treatment. Limitations of the study; caloric test, dynamic visual acuity and dynamic balance tests or scale were not performed in patient selection.

Our results have shown that vHIT is not determinative in diagnosing BPPV and evaluating the efficacy of therapeutic maneuvers, but only subjective methods in which the individual evaluates his/her own perception of dizziness support improvement. In future studies, different tests evaluating VOR in individuals with BPPV can be used together with vHIT. Individuals with recurrent BPPV and individuals with different semicircular canal involvement can be evaluated with vHIT.Results to be obtained from studies including individuals with recurrent BPPV may provide further information on the role of vHIT in assessing the efficacy of therapeutic maneuvers.

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Declaration of Conflicting Interest

The authors declare no conflicts of interest.

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