Research Article

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VOR Cancellation at the patient's bedside: how to avoid another cause of false positive

Abstract

There is little literature on the semiological aspects of the clinical Vestibulo-Occulomotor Reflex (VOR) cancellation technique. This study aims to determine which would be the best head movement frequency cutoff to perform the VOR cancellation clinical test. Materials and methods: 98 horizontal semicircular canals with normal gains from normal individuals were included. The VOR was cancelled by placing a headband with a fixed target over the individual's head, and the patient was told to keep their eyes on the target while the examiner recorded the presence and number of saccades that were evident with the naked eye by performing sinusoidal cephalic rotations at different frequencies. The head rotation frequency was compared with the following variables: 1-Saccades that are evident with the naked eye -SHIMP (+) clinical-, 2-The presence of saccades performed for a period of 2 seconds, 3- The presence of saccades performed in every cycle, 4- Amplitude in °/sec. of the performed saccades, 5-Percentage of VOR cancellation and 6-Age. Conclusion: To avoid a false positive caused by SHIMP saccades during the clinical evaluation of the VOR cancellation at the patient's bedside, we recommend performing cephalic rotations with frequencies lower than 0.5Hz - 0.6Hz for the age group under 67 years old. In patients older than and equal to 67 years old, the interpretation of the VOR cancellation using this method should be cautious, and it should be performed with glasses if worn.

Keywords: vestibulo-cular reflex cancellation, SHIMP saccades, SHIMP headband

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Introduction

There is little literature in the world on the semiological aspects of the clinical Vestibulo-Oculomotor Reflex (VOR) cancellation technique since David Zee's publication and his original work in 1977.[1] There is no consensus on which technique should be performed for the exploration of VOR cancellation from the clinical point of view. There are only expert experiences, some descriptions of a few lines and many tutorials in the social media. When we refer to the technique, it includes everything from the maneuver, to how often and what frequency and angular velocity of the head it should be used. Thus, we have descriptions by Dr. Adolfo Bronstein where he explains that the frequency should be of 0.5Hz or less and other descriptions in the medical literature.[2,3] Ronald Tusa in Susan Herdamnn's book talks about performing it at 1 Hz.[4] The most complete description we found was that of David Newman Toker, where in addition to talking about the technique, he mentions interpretation "pearls" and errors linked to False Positive and False Negative situations.[5] It is interesting to note that in his work about the false positives, Newman Toker does not mention the presence of refixation saccades during VOR suppression (SHIMP) as such, since these are observed during the VOR cancellation test at 0.5 Hz, as presented by Dr. Francisco Zuma e Maia in his work.[6] The visual subsystems express the sensitivity according to the frequency at a VOR function of 0.2Hz.[7] The trained eyes of experts, as presented in our HIMP & SHIMP headband study, are capable of seeing saccades of any kind; therefore, when performing the VOR cancellation assessment, it is to be expected that a trained specialist will have more false positives (F(+)) than an inexperienced eye.[8] In this study we seek to determine the best cutoff in terms of frequency and age of the patient to perform the rotational movement of the head for the VOR cancellation clinical test in better semiological conditions, avoiding one of the False Positives of this test in the clinical practice, such as SHIMP saccades.

Materials and methods

The study included 98 horizontal semicircular canals (HSC) with normal gains between 0.8 and 1.3, from healthy individuals with no pathologies that were evaluated clinically and by Video Head Impulse Test (vHIT) and Video-Nystagmography (VNG). An Interacoustics vHIT was used to measure the gain, with previous calibration and at a distance of 1.25 m, taking 15 records randomly to the right and left. Secondly, in order to cancel the VOR, a headband with a fixed target was placed on the patient's head 24 cm away[8] and the patient was instructed to keep their eyes on the target while the examiner observes and records the presence and number of saccades that are evident with the naked eye while performing sinusoidal rotations at different frequencies in the plane of cephalic rotations (yaw plane). We chose to evaluate the frequency because it is easier for human beings to track the frequency (rhythm) in their minds than to estimate the speed of the head in °/s. The examiner was always the same, with more than 15 years of experience in saccade identification. Concomitantly using the same Interacoustic Goggle, we registered the following: eye speed, head speed, head movement frequency, presence and amplitude of refixation saccades. We calculated the gain during VOR cancellation at different frequencies, and the VOR gain was subtracted from these values to determine the VOR cancellation percentage. The head rotation frequency was compared with the following variables: 1-Saccades that are evident with the naked eye -SHIMP (+) clinical-, 2-The presence of saccades performed for a period of 2 seconds, 3- The presence of saccades performed in every cycle, 4- Amplitude of the performed saccades, 5-Percentage of VOR cancellation and 6-Age.

Statistical analysis: The linear correlation analysis was performed between the frequency of cephalic rotation and each of the variables of interest. By using a simple linear regression model, we studied how the frequency of cephalic rotations explains the number of performed saccades per cycle and per unit of time (every 2 seconds), the amplitude of SHIMP saccades and the percentage of VOR cancellation. The angular coefficients of the regression line and the correlation coefficients were calculated and interpreted. The statistical significance of each model and the significance of the correlation coefficient were studied. A test of independence was performed to study the association between the cephalic rotation (higher and lower than 0.6 Hz) and the presence of clinical SHIMP saccades. A significance level of 5% was used in all tests. All calculations, tables and graphs were performed with IBM SPSS Statistics Version 24.

Results

In the sample of 98 pieces of data, cephalic rotation was evaluated vs 6 variables: age, presence of clinical SHIMP saccades, number of saccades performed in a period of 2 seconds, presence of saccades performed in each cycle, average amplitude of SHIMP saccades, percentage of VOR cancellation and age. Ages ranged from 9 to 92 years old, with an average of 55.33 and a standard deviation (SD) of 20,398. Regarding the cephalic rotation, it ranged from 0.06 and 1.8 Hz, with a mean of 0.78 Hz and a SD of 0.382 Hz.

1-Cephalic rotation (Hz) vs Presence of Cases with Clinical SHIMP Saccades:

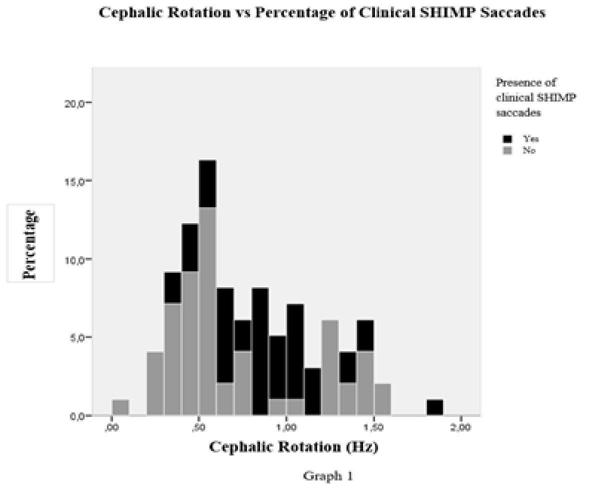
Distribution of the different cases according to the cephalic rotation in Hz (Table 1). Presence of clinical SHIMP saccades according to the cephalic rotation above and below 0.6 Hz, in absolute numbers and percentage. The association between the presence of SHIMP saccades and the presence of cephalic rotation greater than 0.6 Hz was studied, obtaining a chi-square equal to 17.01 (p=0.000). Therefore, we can state that there is a statistically significant association between the presence of SHIMP saccades and the presence of cephalic rotation greater than 0.6 Hz (Table 2). Presence of SHIMP saccades according to the cephalic rotation in Hz (Graph 1)

Table 1 Distribution of the different cases according to the cephalic rotation in Hz

Distribution of the different cases according to the cephalic rotation (Hz)			
Cephalic Rotation (Hz)	**Number of cases**	**Percentage**	**Cumulative percentage**
From 0 to 0.19	1	1	1
From 0.2 to 0.39	13	13.3	14.3
From 0.4 to 0.59	28	28.6	42.9
From 0.6 to 0.79	14	14.3	57.1
From 0.8 to 0.99	13	13.3	70.4
From 1 to 1.19	10	10.2	80.6
From 1.2 to 1.39	10	10.2	90.8
From 1.4 to 1.59	8	8.2	99
From 1.8 to 1.99	1	1	100
Total	98	100	

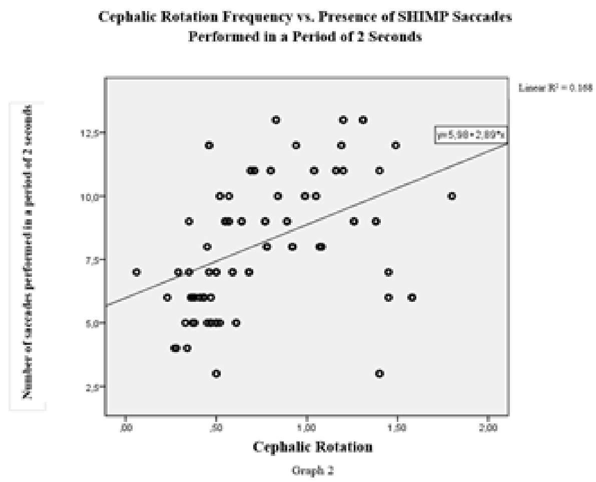
Table 2 Presence of SHIMP saccades and the presence of cephalic rotation greater than 0.6 Hz

Cephalic Rotation Presence of Clinical SHIMP Saccades				
		Presence of clinical SHIMP saccades		
		No	**Yes**	**Total**
Cephalic Rotation	From 0 to 0.6	34 (81.0%)	8 (19.0%)	42 (100%)
	More than 0.6	22 (39.3%)	34 (60.7%)	56 (100%)
Total		56 (57.1%)	42 (42.9%)	98 (100%)



Graph 1 Presence of SHIMP saccades according to the cephalic rotation in Hz.

2-Frequency of Cephalic Rotation vs. Presence of SHIMP Saccades Performed for a Period of 2 Seconds (Graph 2). A Pearson linear correlation coefficient equal to 0.410 (p=0.000) was calculated. The coefficient of determination was of 0.1681. The regression line is: Number of saccades = 5,984 + 2,888*Rotation. For every 0.1 Hz increase in cephalic rotation in Hz, the number of saccades performed in 2 seconds increases by an average of 0.289 saccades (p=0.000).

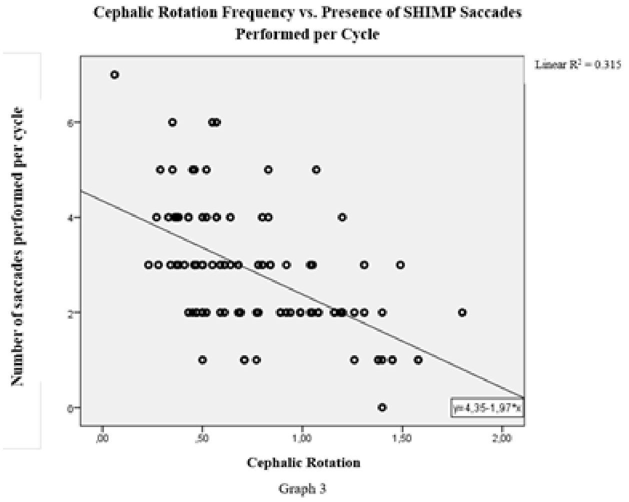


Graph 2 Frequency of cephalic rotation vs presence of SHIMP saccades performed for a period of 2 seconds.

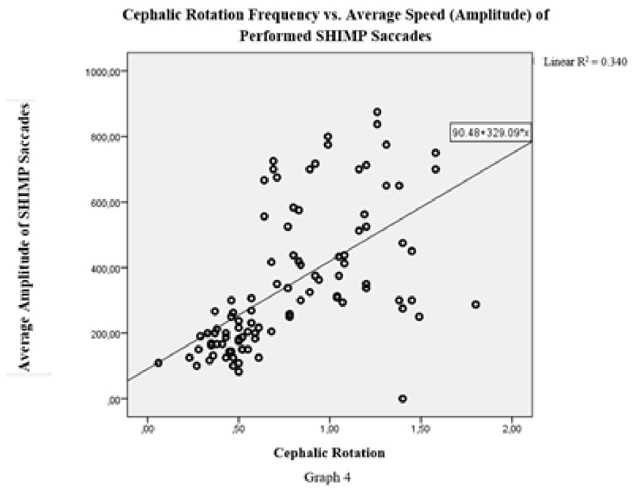
3-Frequency of Cephalic Rotation vs. Presence of SHIMP Saccades Performed per Cycle. (Graph 3) The Pearson linear correlation coefficient is equal to -0.561 (p=0.000). The coefficient of determination was of 0,315. The regression line is: Number of saccades per cycle = 4,345– 1,966*Rotation. For every 0.1 Hz increase in cephalic rotation in Hz, the number of saccades performed per cycle decreases by an average of 0.197 saccades (p=0.000).

Graph 3.

4-Frequency of Cephalic Rotation (Hz) vs Average Speed (Amplitude) of Performed SHIMP Saccades (Graph 4) The Pearson linear correlation coefficient is 0.583 (p=0.000) and the coefficient of determination is 0.340. The fitted regression line was found to be: Amplitude = 90.484 + 329.09*Rotation. For every 0.1 Hz increase in cephalic rotation, the average amplitude of SHIMP saccades increases on average 32.91°/s.



Graph 3 Frequency of cephalic rotation vs. presence of SHIMP saccades performed per cycle.



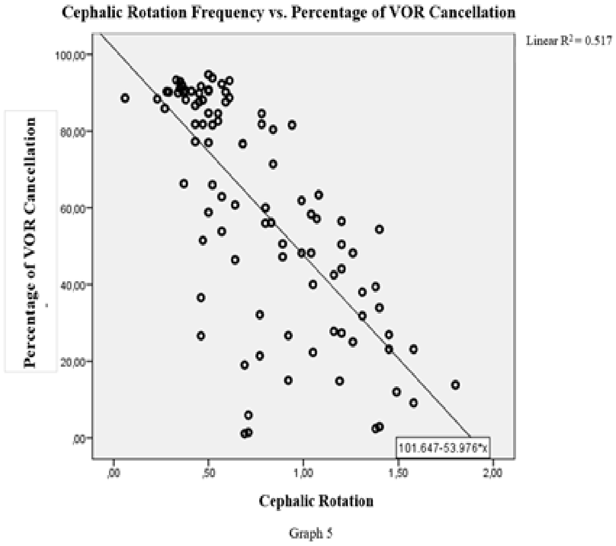
Graph 4 Frequency of cephalic rotation (hz) vs average speed (amplitude) of performed SHIMP saccades.

5-Frequency of Cephalic Rotation Hz vs. Percentage of VOR Cancellation (Graph 5). The correlation coefficient was found to be -0.719 (p=0.000) and the coefficient of determination 0.517. The resulting regression line is: Percentage of VOR Cancellation = 101.647 – 53.976*Rotation. For every 0.1 Hz increase in cephalic rotation frequency, the VOR cancellation percentage decreases by an average of 5.4%.

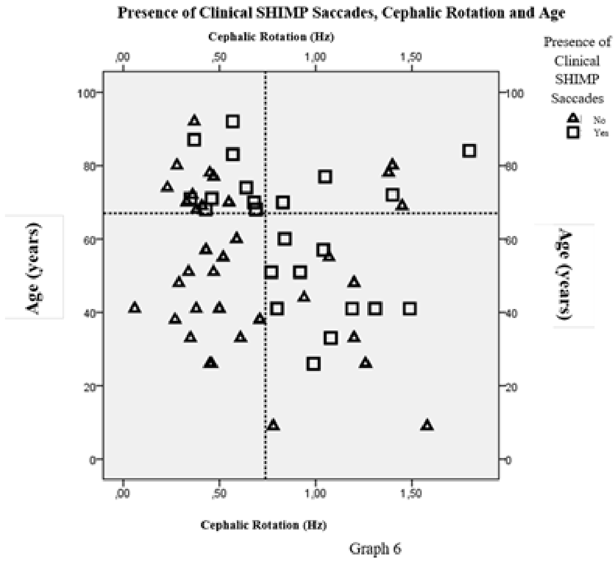
6-Presence of Clinical SHIMP Saccades, Cephalic Rotation and Age (Table 3) (Graph 6).

Table 3 Presence of clinical SHIMP saccades, cephalic rotation and age

Percentage of Clinical SHIMP Saccades			
		Cephalic Rotation (Hz)	
		Less than 0.74	**0.74 or more**
Age	67 years old or more	53.80%	50%
	Less than 67 years old	0%	60%



Graph 5 Frequency of cephalic rotation hz vs percentage of VOR cancellation.



Graph 6 Presence of clinical SHIMP saccades, cephalic rotation and age.

We observed that at a frequency equal to or lower than 0.74 Hz and at an age equal to or lower than 67 years old, no clinical SHIMP saccades were observed. On the other hand, at ages older than 67 years old, with a frequency less than or equal to 0.74Hz, 50% of the individuals present clinical SHIMP saccades (9 out of 18). At a frequency greater than 0.74 Hz in individuals older than 67 years old, 57.1% (4 out of 7) present clinical SHIMP saccades. At a frequency greater than 0.74 Hz in individuals younger than 67 years old, 58.8% (10 out of 17) present clinical SHIMP saccades.

Discussion

As we know, refixation saccades in the SHIMP mode appear in normal individuals[3] which could create confusion with saccades caused by altered VOR suppression in cerebellar flocculus lesions, as a result of not performing this test correctly.

When analyzing the results of the presence of clinical SHIMP saccades (with naked eye) according to the head rotation frequency, we see that these are more frequent between 0.6 Hz and 1.2 Hz (Table

2) (Graph 1). As the frequency of cephalic rotation increases, the number of cases with refixation saccades in SHIMP mode identified by the examiner increases because VOR cancellation becomes less efficient as the frequency increases. As we can see in Graph 1, Table 2, there appears to be a frequency cutoff at 0.6 Hz, where the increase in SHIMP saccades is clearly observed. We believe that the dramatic drop in saccades after 1.2 Hz would be linked to the fact that fewer saccades per cycle are clinically identified (as it can be seen in Figure 3), making them more difficult to see with the naked eye, although the total number per unit of time increases, as it can be seen in Graph 2 of saccades in a period of 2 seconds.

When analyzing the number of saccades performed in a period of 2 seconds with respect to cephalic rotation, in Graph 2 we noticed a positive correlation, with the presence of outliers at a high rotation frequency, greater than 1.3 Hz. The Pearson linear correlation coefficient of 0.410 (p=0.000), allows us to affirm that there is a moderate and positive correlation between cephalic rotation in Hz and the number of saccades performed in a period of 2 seconds. For every 0.1 Hz increase in cephalic rotation in Hz, the number of saccades performed in 2 seconds increases by an average of 0.289 saccades (p=0.000).

When analyzing the number of saccades performed per cycle, there is a negative correlation with cephalic rotation. Pearson linear correlation coefficient of -0.561 (p=0.000), allows us to affirm that there is a moderate and negative correlation between cephalic rotation in Hz and the number of saccades performed per cycle. For every 0.1 Hz increase in cephalic rotation, the number of saccades performed per cycle decreases on average by 0.197 saccades (p=0.000); this explains why clinically, with the naked eye, we cannot observe SHIMP saccades as the frequency increases especially above 1.2 to 1.3 Hz.

Cephalic rotation is positively correlated with the speed (amplitude) of SHIMP saccades. The Pearson linear correlation coefficient is 0.583 (p=0.000) and the coefficient of determination is 0.340. For every 0.1 Hz increase in cephalic rotation, the average amplitude of SHIMP saccades increases on average 32.91°/s. When compared with the other variables, cephalic rotation is more related to amplitude than to the presence of saccades. As in the study of the other variables, values that deviate from the trend line emerge when the cephalic rotation reaches high values greater than 1.2 Hz.

The percentage of VOR cancellation is negatively correlated with cephalic rotation. The correlation coefficient was found to be -0.719 (p=0.000) and the coefficient of determination 0.517. For every 0.1 Hz increase in cephalic rotation frequency, the VOR cancellation percentage decreases by an average of 5.4%. It is to be expected that as the frequency of cephalic rotation increases, the VOR cancellation mechanism becomes saturated.

Clinical SHIMP saccades seem to depend not only on the frequency of the cephalic rotation, but also on age or a combination of both variables.[9] In Graph 6, we see the age and the cephalic rotation corresponding to each measurement, with a square symbol indicating the presence of clinical SHIMP saccades. The vertical line marks a cephalic rotation cutoff of 0.74 Hz and the horizontal line marks a cutoff at 67 years old. In Table 3, we see that at a frequency lower than 0.74 Hz and an age less than or equal to 67 years old, there is no presence of clinical SHIMP saccades (0%). On the other hand, at the same frequency cutoff, but above 67 years old, 53.8% of the cases presented clinical SHIMP saccades. In the same age group, at a cephalic rotation frequency greater than or equal to 0.74Hz, 50% presented clinical SHIMP saccades. At a frequency higher than 0.74 Hz and in individuals under 67 years old, there were clinical SHIMP saccades in 60% of cases. The results above 0.74 Hz could be due to the fact that we are dealing with a small sample; however, it could be said that there are indications that the presence of clinical SHIMP saccades would occur mainly at frequencies equal to or higher than 0.74Hz, and in people over 67 years old at any rotation frequency, which could be explained by the inability to maintain a clear vision on the headband target due to presbyopia, since it is 24 cm away from the forehead of the examinee, or by the possibility that there is an aging of the VOR cancellation, or both mechanisms.

Conclusion

To avoid a false positive (F(+)) caused by SHIMP saccades during the clinical evaluation of the VOR cancellation at the patient's bedside, we recommend performing cephalic rotations with frequencies lower than 0.5Hz - 0.6Hz for the age group under 67 years old. In patients older than and equal to 67 years old, the interpretation of the VOR cancellation using this method should be cautious, and it should be performed with glasses if worn.

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Conflict of Interests

Authors declare no conflict of interests.

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References

1. Zee DS. Supression of vestibular nystagmus. *Ann Neurol*. 1977;1(2):207.
2. Michael Strupp, Thomas Brandt. Diagnosis and treatment of vertigo and dizziness. *Dtsch Arztebl Int*. 2008;105(10):173–180.
3. Zuma e Maia CF, Carmona S, Selamein da Costa S. Avaliacao Clínica do Paciente Vertiginoso. *Otoneurologia Atual Francisco*. Revinter. RJ Brazil 2015. 34 p.
4. Susan J Herdman. Vestibular rehabilitation. *Curr Opin Neurol*. 2013;26(1):96–101.
5. Newman Toker D. Neuro-vestibular examination. *Neuro-Ophthalmology*. Virtual Education Library.
6. Faria Ramos B, Cal R, Carmona S, et al. Corrective saccades in unilateral and bilateral vestibular hypofunction during slow rotation expressed by visually enhaced VOR and VOR supression: role of the cerebellum. the cerebellum. *Cerebellum*. 2021;20(5):673–677.
7. Christopher McCrum, Gaspar Epro, Gert-Peter Brüggemann, et al. Visual and proprioceptive contributions to postural control of upright stance in unilateral vestibulopathy. *Somatosens Mot Res*. 2016;33(2):72–78.
8. D'Albora R, Noboa R, Road JC, et al. Clinical testing of head impulse paradism using a diagnostic headband: combination clinical sign for improved performance. Otol Neurotol. 2022;43(2):e268–e273.
9. Lee JY, Kim MB. Effect of aging and direction of impulse in suppression head impulse test. Otol Neurotol. 2020;41(10):e1231–e1236.