

# Behavior of the posterior semicircular canal after Dix-Hallpike maneuver

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## Abstract

The objective of the present study is to analyze the quantitative vestibulo-ocular responses in a group of patients with benign paroxysmal positional vertigo (BPPV) canalolithiasis and compare these data with the data of the tridimensional biomechanical model. This study was conducted on 70 patients that presented idiopathic posterior semicircular canal canalolithiasis. The diagnosis was obtained by Dix-Hallpike maneuvers recorded by videonystagmograph. The present study demonstrates that there is a significant correlation between the intensity of the nystagmus and its latency in cases of BPPV-idiopathic posterior semicircular canal canalolithiasis type. These findings are in agreement with those obtained in a tridimensional biomechanical model and are not related to the patients' age.

## Introduction

Benign paroxysmal positional vertigo (BPPV) is the most common vestibular disorder, occurring in approximately 64 of each group of 100,000 patients each year. According to Hughes and Proctor, it was first described by Alfred Adler in 1897 as *paroxysmal vertigo*.<sup>1</sup> Robert Bárány, in 1921, reported a case as a *paroxysmal vertigo with nystagmus following changes in head position*.<sup>2</sup> The term *benign paroxysmal positional vertigo* was proposed by Dix and Hallpike in a study that included a detailed report on the clinical characteristics of the disorder.<sup>3</sup>

BPPV is characterized by brief episodes of vertigo, unsteadiness and nausea. These symptoms are typically precipitated by a change in ori-

entation of the head or body in relation to gravity. These positional changes often occur during common activities such as lying down in bed or reaching up to retrieve an object from a high shelf.

The positional changes induce loose macular otoliths to move inside the labyrinth in order to attain a location with a minimal potential energy. The movement of the particles in the ducts, being opposed to the endolymph viscosity, generates shearing forces that result in endolymph displacement and a deflection of the cupula that the brain interprets as a dynamic head rotation.<sup>2</sup>

Dix and Hallpike<sup>3</sup> identified the semicircular canals as the origin of the neural impulses to the brain responsible for the BPPV symptoms. They also introduced the most frequently used clinical test for the diagnosis of the condition, the Dix and Hallpike maneuver; it consists of a reorientation of the head to align the posterior semicircular canal at its entrance to the ampulla with the direction of gravity. The patient is then submitted to linear and angular accelerations. These stimuli are very effective in producing vestibular responses in patients with BPPV.

In most of the patients with BPPV the cause of the otoliths' displacement is unknown. The anatomical characteristics of the posterior semicircular canal, however, seems to render it more sensitive to receive the loose otoliths when the patient is in supine position, as a consequence of the action of gravity on the particles arising from the crus commune.

The observations during provocative head reorientation related to gravity show that most BPPV cases could be classified according to two types of responses.

The first type of response is characterized by constant nystagmus observed after the head has been reoriented. This nystagmus is due to a maintained gravity-dependent excitation of the posterior canal ampulla, characteristic of *cupulolithiasis*, a condition in which displaced otoliths become attached to the cupula.

The second, and most common responses elicited by the Dix-Hallpike maneuver, is characterized by a delayed torsional-vertical nystagmus with the fast phase directed toward the lower ear. The nystagmus decays over time after the head has been reoriented and typically reverses direction when the head is returned to its original orientation. These eye movements have a latency of 1 to 10 s and usually last from 5 to 60 s<sup>4-6</sup> The latency, limited duration, reversal, and fatigability of the nystagmus are consistent with the pathological presence of loose utricular otoliths within the lumen of the membranous labyrinth-a condition called *canalolithiasis*.<sup>7-9</sup>

Rajguru *et al.*<sup>10</sup> developed a mathematical tridimensional model to quantify the biomechanical origin of the gravity induced responses of the semicircular canals in the presence of canalolithiasis. This model predicts the latency and intensity of the nystagmus resulting from the Dix-Hallpike maneuver. It was observed that the latency peaks, which are related to the length of time taken by the particles to move from the ampulla to the posterior apex of the canal, were essentially dependent on the *size* and *number* of the particles. Small particles were correlated to long latencies, small intensities and reduced cupula displacements;

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large particles, or groups of small particles, yielded short latencies. The intensity of the responses was essentially dependent on the number of particles. In spite of the fact that this study was focused on biomechanics, according to the authors, the model can be applied to the clinical interpretation of eye movements, complementing these results with the role of the vestibulo-ocular reflex system.

The objective of the present cohort transversal study is to analyze the quantitative vestibulo-ocular responses in a group of patients with BPPV - idiopathic posterior semicircular canal canalolithiasis type and compare these data with the theory of the tridimensional biomechanical model.

## Materials and Methods

This study was conducted by analyzing the video recordings of the examinations of 70 patients diagnosed with idiopathic posterior semicircular canal canalolithiasis BPPV in a private service of otolaryngology, during the years 2012 to 2014. The diagnosis was obtained by means of Dix-Hallpike maneuvers, processed according to the literature:<sup>10,11</sup> the patient was positioned on the examination table so that, on lying flat, the head would extend over the end of the table. The head was then positioned at an angle of 45° to the right side, and the patient was brought down to the head-right supine position. After 20 s the patient was sat up again, and the procedure was repeated to the left (head-left supine position). The tests were performed by the same examiner and recorded by video Frenzel's goggles utilizing an Interacoustic Otoaccess program that measures only the latency and duration of quantitatively nystagmus. Intensity was used for the qualitative measure. Patients with BPPV associated with other disorders, such as Menière's disease, vestibular neuritis and cranial trauma were excluded.

The following variables were statistically analyzed: patient's gender,

ages, latencies, intensities and durations of the nystagmus. The statistical tests were performed with a SPSS 18 program.

## Results

The gender distribution of the patients showed that BPPV was found to be more frequent in female patients – 73% against 27% males. The posterior semicircular canal on the right side was involved in 63% of the cases, the left in 37%. The patients' ages went from 41 to 70 years.

Patients' ages, latencies and durations were plotted in relation to intensity levels. Only the latencies showed significant differences: lower intensities corresponded to longer latencies ( $r < 0.05$ ) than those observed with middle and high intensities (Table 1).

The correlation between age and latencies was  $-0.01$  ( $r=0.942$ ). The value for the correlation between latency and duration and age and duration were, respectively,  $0.03$  ( $r=0.810$ ) and  $-0.04$  ( $r=0.719$ ). None of these comparisons were statistically significant. The comparisons of latencies and durations in different age groups also did not show statistical significance (Tables 2 and 3).

## Discussion

The results of the present study are in agreement with those reported in the literature regarding the genders, affected sides, latencies, duration of the nystagmus and ages of the patients with BPPV.<sup>12</sup>

It has been observed, in clinical practice, that there are considerable variations in the responses elicited by Dix-Hallpike maneuvers regarding the latencies, intensities and duration of the nystagmus, in patients with BPPV-idiopathic posterior semicircular canal canalolithiasis type.

A significant correlation was observed in this group of patients between the intensities and the latencies of the nystagmus after the

**Table 1. Comparisons between the intensity of responses and patients' ages, latencies and durations.**

Intensity	Age		Latency		Duration	
	N	Mean (SD)	N	Mean (SD)	N	Mean (SD)
Small	18	54.22 (16.10)	18	8.45 (3.77)*	18	34.33 (22.74)
Medium	29	57.86 (13.89)	29	6.15 (2.76)	29	25.61 (16.61)
High	23	52.78 (16.66)	23	4.93 (1.97)	23	29.35 (18.89)
r-value <sup>o</sup>		0.641		0.001		0.343

SD, standard deviation. \*Statistical significance in comparison with medium and high; <sup>o</sup>referred to Kruskal-Wallis' test.

**Table 2. Comparisons between patients' ages and nystagmus latencies.**

Age	N	Mean	Standard deviation	r-value*
Up to 47 years	23	6.90	4.02	0.874
From 48 to 62 years	24	6.21	3.10	
63 years or more	23	5.93	1.91	

\*Referred to Kruskal-Wallis' test.

**Table 3. Comparisons between patients' ages and nystagmus durations.**

Age	N	Mean	Standard deviation	r-value*
Up 47 years	23	32.38	19.49	0.259
From 48 to 62 years	24	25.37	17.98	
63 years or more	23	29.66	20.0	

\*Referred to Kruskal-Wallis' test.

Dix-Hallpike maneuver: long latencies are correlated to small intensities, medium latencies correlate to middle intensities and short latencies correlate to high intensities, in agreement with the tridimensional biomechanical model.

A comparison of these results suggests that most probably these patients had isolated otoliths, or groups of otoliths with different weights, floating in the endolymph, which would account for the different latencies and intensities of the nystagmus.

We do not have an objective finding to confirm the hypothesis of the relationship between size and number of the particles and the latency or intensity of the nystagmus. This paper, however, is based on an theoretical hypothesis, having a 3D model as reference. Unfortunately it is impossible to confirm these data, due to the lack of objective ways to prove them. The idea of this hypothesis is to show another way of thinking about BPPV and its relation between latency/intensity and the size/number of the otoliths.

There was no significant correlation between the latencies and durations of the nystagmus.

No correlation, also, was observed between the patients' ages and the variables that were evaluated, which suggests that the number of otoliths that float in endolymph has no relation with the patients' ages.

These results suggest that clinical studies related to canalolithiasis BPPV should take in consideration the values of latencies, durations and intensities of the nystagmus resulting from Dix-Hallpike maneuvers, since these data can be possibly related to the results obtained with the particle repositioning maneuvers of Epley and Semont.

## Conclusions

The present study demonstrates that there is a significant correlation between the intensity of the nystagmus and its latency in cases of BPPV-idiopathic posterior semicircular canal canalolithiasis type. These findings are in agreement with those obtained in a tridimensional biomechanical model and are not related to the patients' ages.

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