Research, Society and Development, v. 12, n. 4, e21212441173, 2023
(CC BY 4.0) | ISSN 2525-3409 | DOI: http://dx.doi.org/10.33448/rsd-v12i4.41173

Proposal of an otolith repositioning maneuver for posterior canal Benign Paroxysmal Positional Vertigo: a supine-seated approach

Proposta de uma manobra de reposicionamento otolítico para Vertigem Posicional Paroxística Benigna do canal posterior: uma abordagem em posição supina para sentado

Propuesta de una maniobra de reposicionamiento otolitico para el Vértigo Posicional Paroxístico Benigno del canal posterior: abordaje de supino a sentado

Received: 03/24/2023 | Revised: 04/07/2023 | Accepted: 04/08/2023 | Published: 04/13/2023

Guilherme Dias Rocha
ORCID: https://orcid.org/0000-0002-6908-8261
Centro de Audiologia e Pesquisa em Equilíbrio, Brazil
E-mail: guilherme.audio@gmail.com
Ana Paula Lefèvre
ORCID: https://orcid.org/0000-0001-5919-7942
Escola Nacional de Saúde Integrada, Brazil
E-mail: analefevre@ensi.com.br

Abstract
Background: Benign Paroxysmal Positional Vertigo (BPPV) is one of the most frequent pathologies of the vestibular system. The treatment maneuvers involve changes in the position of the head, as proposed by previous research. The objective of this research was to describe a new otolith repositioning maneuver in supine position for patients diagnosed with posterior canal BPPV due to canalithiasis. Methods: we described a new otolith repositioning maneuver that does not involve a change of position in decubitus, being performed in the supine to sitting position. This is an uncontrolled clinical study to evaluate the effects of maneuver after 1 hour and after 1 week. Results: The present study obtained a success rate (abolition of nystagmus and positional vertigo) in 85.19% of patients after a single application of the new maneuver presented and in a further 9.26% after two maneuvers, totaling 94.44% success rate with 1 or 2 maneuvers performed on the same day. Conclusions: The new maneuver studied eliminated nystagmus and positional vertigo in most patients with PC BPPV. It may be preferred for patients who have difficulties in performing maneuvers that involve changing body position on the narrow stretcher and the execution of the lateral decubitus position.
Keywords: Benign paroxysmal positional vertigo; Rehabilitation.

Resumo
Introdução: A Vertigem Posicional Paroxística Benigna (VPPB) é uma das patologias mais frequentes do sistema vestibular. As manobras de tratamento envolvem mudanças na posição da cabeça, conforme proposto por pesquisas anteriores. O objetivo desta pesquisa foi descrever uma nova manobra de reposicionamento otolítico em decúbito dorsal para pacientes diagnosticados com VPPB de canal posterior devido a canalitíase. Métodos: descrevemos uma nova manobra de reposicionamento otolitico que não envolve mudança de posição em decúbito, sendo realizada da posição supina para sentada. Este é um estudo clínico não controlado para avaliar os efeitos da manobra após 1 hora e após 1 semana. Resultados: O presente estudo obteve taxa de sucesso (abolição do nistagmo e vertigem posicional) em 85,19% dos pacientes após uma única aplicação da nova manobra apresentada e em mais 9,26% após duas manobras, totalizando 94,44% de taxa de sucesso com 1 ou 2 manobras realizadas no mesmo dia. Conclusões: A nova manobra estudada eliminou o nistagmo e a vertigem posicional na maioria dos pacientes com VPPB. Pode ser preferencial para pacientes que apresentam dificuldades em realizar manobras que envolvam a mudança de posição corporal na maca estreita e a execução do decúbito lateral.
Palavras-chave: Vertigem posicional paroxística benigna; Reabilitação.

Resumen
Introducción: El vértigo posicional paroxístico benigno (VPPB) es una de las patologías más frecuentes del sistema vestibular. Las maniobras de tratamiento involucran cambios en la posición de la cabeza, como lo proponen investigaciones previas. El objetivo de esta investigación fue describir una nueva maniobra de reposicionamiento de otolitos en decúbito dorsal para pacientes diagnosticados de VPPB del canal posterior por canalitiasis. Métodos: describimos una nueva maniobra de reposicionamiento otolítico que no implica cambiar de posición en decúbito,

realizándose desde la posición supina a la sentada. Este es un estudio clínico no controlado para evaluar los efectos de la maniobra después de 1 hora y después de 1 semana. Resultados: El presente estudio obtuvo una tasa de éxito (supresión del nistagmo y vértigo posicional) en el 85,19% de los pacientes tras una sola aplicación de la nueva maniobra presentada y en otro 9,26% tras dos maniobras, totalizando un 94,44% de éxito con 1 o 2 maniobras realizadas el mismo día. Conclusiones: La nueva maniobra estudiada eliminó el nistagmo y el vértigo posicional en la mayoría de los pacientes con VPPB. Puede ser preferible para pacientes que tienen dificultades para realizar maniobras que impliquen cambiar la posición del cuerpo en una camilla estrecha y realizar decúbito lateral.
Palabras clave: Vértigo posicional paroxístico benigno; Rehabilitación.

1. Introduction

Benign Paroxysmal Positional Vertigo (BPPV) is one of the most frequent pathologies of the vestibular system. It is clinically characterized by the presence of recurrent episodes of vertigo, typically triggered by certain head movements or changes in postures per-formed by the patient (Chang et al., 2016; Maslovara et al., 2018; Instrum et al., 2019). Studies indicate a higher occurrence of BPPV in women (Kaur et al., 2017; Lou et al., 2020).

Symptoms tend to resolve spontaneously after a few weeks or months. Some patients, however, experience recurrence months or years later, ranging from short episodes to decades of suffering with short intervals of remission. Diagnostic confirmation can be obtained by Dix-Hallpike Test (DHT). The maneuver is considered positive when it triggers vertigo and nystagmus by changing the position of the individual from sitting to lying with their head sustained below the horizontal plane, with a rotation of 45° to the side to be tested (Bhattacharyya et al., 2017; Kim et al., 2020).

The clinical findings of BPPV are consistent with the hypothesis that the semicircular canals, with a much higher incidence in the posterior, contain floating particles, or debris, that are heavier than circulating endolymph (Kim et al., 2020).

Each region with free debris requires a different treatment strategy through maneuvers composed of head movements to restore normal semicircular function and thus eliminate positional nystagmus and vertigo (Yao et al., 2018).

The treatment maneuvers involve changes in the position of the head in series of repetitions, as proposed by Brandt and Daroff, the Semont liberatory maneuver, the canalicular repositioning procedure, among others. The main objective of the maneuvers is to re-position the free debris of the semicircular canal in the utricle. The maneuvers seek to achieve mechanisms of adaptation and compensation in the central nervous system, aiming at overcoming symptoms (Kim et al., 2020).

In the Semont maneuver, the patient is placed sitting laterally on the stretcher and then lied down to the affected side with the head 45° up. The patient is then quickly shift-ed from side to side, passing through the sitting position and ending on the contralateral side with the head 45º down. Many authors consider the maneuver aggressive, because it often triggers severe dizziness, and therefore it isn't well tolerated by patients (Imai et al., 2017).

In the Epley maneuver, the first movement is the same as the Dix and Hallpike maneuver, being performed with the ear affected in the lower position. From this first position, the head is rotated towards the contralateral ear up to 45º in relation to the vertical plane. From the second head position, the patient has his trunk and legs laterally rotated the side opposite the affected ear, ending with the head positioned about 135º towards the vertical plane (with the face towards the ground). From this third position, the patient has his trunk raised laterally in block, until he finishes sitting sideways on the stretcher, and returns the head to the orthostatic position (Imai et al., 2017; Mandalà et al., 2019; Power et al., 2020).

Some patients may have difficulties in performing maneuvers that involve changes in body position on the stretcher, such as the obese, the elderly and people with orthopedic or surgical restrictions. Therefore, the general objective of this study is to describe and evaluate the effects of an otolith repositioning maneuver for patients diagnosed with posterior canal benign paroxysmal positional vertigo performed from supine to sitting position.

2. Methodology

We described a new otolith repositioning maneuver that does not involve a change of position in decubitus, being performed in the supine to sitting position. It is intended for patients diagnosed with posterior canal BPPV (PC BPPV) due to canalithiasis.

The objectives of this research were:

1. To describe a new otolith repositioning maneuver in supine position for patients diagnosed with PC BPPV due to canalithiasis.
2. To describe the immediate effects of maneuver after 1 hour (occurrence of vertigo and positional nystagmus).
3. To describe the effects of maneuver after 1 week (occurrence of vertigo and positional nystagmus as well as residual dizziness after the successful maneuver).

This is an uncontrolled clinical study with follow-up, carried out with adults diag-nosed with idiopathic BPPV, based on data collected during four months at the Centro de Audiologia e Pesquisa em Equilíbrio (CAPE), in the city of Rio de Janeiro (Brazil). Patients assisted at the service were invited to participate voluntarily. This study was approved by the Research Ethics Committee of the Instituto Nacional de Educação de Surdos - INES, Rio de Janeiro (CAAE: 63837622.0.0000.8137, number: 5.701.744) and it was conducted in accordance with the Principles of Ethics for Medical Research Involving Human Subjects.

The study included adult patients of both sexes with vestibular complaints who presented test results compatible with BPPV of the posterior semicircular canal whithout impediment to perform the procedure. The following situations were considered impediments to performing the procedure: severe nausea at the time of the maneuver and conditions of extreme limitation of cervical mobility.

Patients with other peripheral vestibular conditions or central disorders were excluded from the sample. All participants were informed and clarified about the objectives and procedures of the research.

For the BPPV diagnosis, the Dix-Hallpike Test (DHT) was performed, using Frenzel goggles without fixation. The patients were seated in an upright position, with their heads turned 45° to the right or left, and then positioned horizontally with head extension over the neck. The diagnosis of PC BPPV requires positive DHT with the following criteria: 1) brief latency between the onset of nystagmus and vertigo and head positioning; 2) presence of paroxysmal torsional nystagmus with upbeating component (rapid component of the upper pole of the torsional movement of the eye towards the lower ear) associated with a perception of vertigo.

The therapeutic intervention studied was performed by a new repositioning maneuver in supine position for sitting, described below. The maneuver was performed by a professional with experience in the field of vestibular evaluation and rehabilitation.

The patient was retested one hour after the first repositioning maneuver and again after one week. In the cases in which the patient still presented nystagmus and positional vertigo after the first retest (one hour after the first maneuver), a second repositioning maneuver was performed and then the patient was tested yet again after one hour.

After the repositioning maneuver, the following parameters were analyzed:

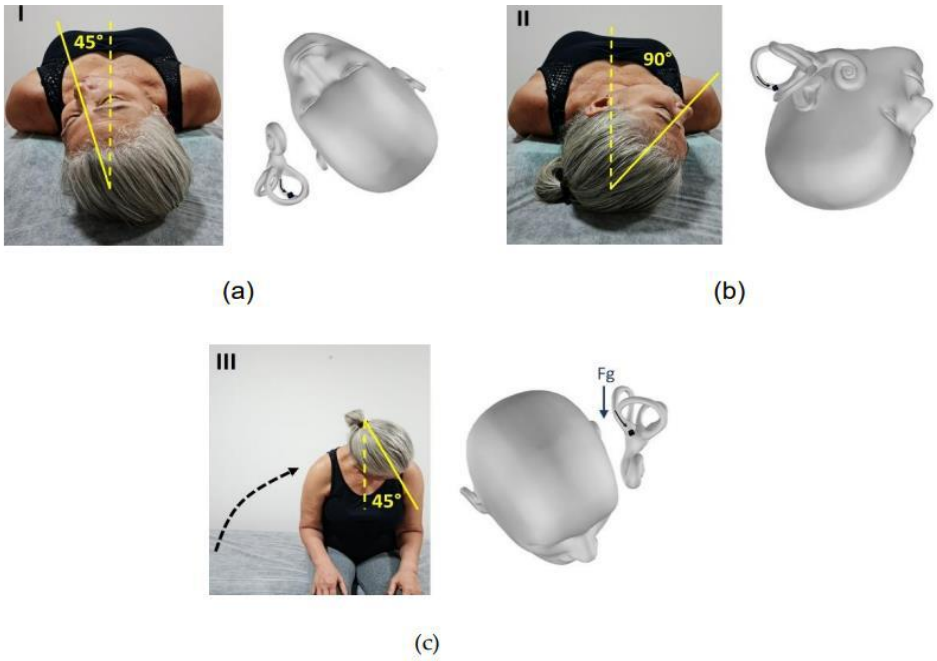
1. Nystagmus and positional vertigo: the negative result (absence of vertigo and nystagmus) after the retest indicates effectiveness of the therapeutic procedure studied.
2. Occurrence of canal conversion.
3. In addition, the patient was asked about the occurrence of residual dizziness after the successful maneuver, as well as its duration.

The collected data were tabulated in a digital spreadsheet (Excel, 2013) and after checking the consistency of the database, descriptive and inferential analysis was per-formed using the statistical program Stata version 13.1.

The variables age, sex and affected side were compared to the presence of nystagmus (positional and vertigo) after the maneuver and residual dizziness when the absence of nystagmus was observed after the maneuver, assuming a level of statistical significance $p < 0.05$.

Description of the new maneuver: "Dias Repositioning Maneuver" is initiated with the patient on the stretcher in the sitting position and consists of three steps. Step I: the patient is asked to lie down in supine position on a cushion positioned at the height of the chest, with the head hyperextension of 20° and rotated 45° to the affected side; being held in this position for 1 minute after the nystagmus ceases. Step II: then the patient's head is rotated 135° toward the opposite side and held in this position for another 2 minutes. Step III: the patient is asked to sit with his head tilted down and rotated 45° to the affected side (Figure 1). During the maneuver, the researcher directed the positioning of the head.

Figure 1 - Dias repositioning maneuver (representation for left PC BPPV): (a) Step I: The patient begins the maneuver by rotating the head 45° to the affected side from the neutral position (dotted line) and lying down with a 20° hyperextension (as in the Dix-Hallpike Test). In this step, the particles move towards the apex of the posterior semicircular canal by the action of gravity. Wait 1 minute after nystagmus ends. (b) Step II: The patient rotates the head 135° toward the unaffected side. To facilitate correct positioning of the head in this step, it is necessary to rotate the head 90° from the neutral position (dotted line). Stay 2 minutes in this position. In this step, the particles move towards the Crus Commune. This angle is important as the particles are closer to the exit of the posterior semicircular canal. (c) Step III: The patient, places the legs off the stretcher, and with the help of the specialist, sits with the head tilted down and rotated 45° towards the affected side from the neutral position (dotted line). Stay 2 minutes in this step. In this position, the non-ampullary arm of the posterior semicircular canal is aligned with the vector of gravity, facilitating the exit of the otoconia and movement towards the utricle. Fg = Force of gravity.



Source: Authors. Centro de Audiologia e Pesquisa em Equilíbrio – CAPE (2023), Brazil.

3. Results

3.1 Patients Characteristics

For 4 months in a row, patients with vestibular complaints assisted at CAPE were invited to participate in the study. The sample consisted of 108 adults of both sexes, diagnosed with PC BPPV with canalitiasis type obtained through the positive Dix-Hallpike test, aged between 26 and 86 years, mean of 63.91 years (std.dev. 12.58) and median of 64 years; 87.04% female (n= 94) (Table 1).

Table 1 - Characterization of patients with PC BPPV, Brazil, 2022 (n=108). F = Female and M = Male.

Variable	n	%
Sex		
F	94	87.04
M	14	12.96
Affected side		
Right	78	72.22
Left	30	27.77
Age group		
up to 30	2	1.85
31 to 40	4	3.70
41 to 50	10	9.26
51 to 60	24	22.22
61 to 70	40	37.04
71 to 80	16	14.81
over 80	12	11.11

Source: Authors.

Regarding the affected side, 78 (72.22%: 95%CI: 62.89% to 79.95%) volunteers had PC BPPV on the right and 30 (27.77%; 95%CI: 20.05% to 37.10%) on the left. The conversion of the canal was also evaluated and was absent in 100% of the sample.

3.2 Dias Repositioning Maneuver results

The first application of the maneuver caused the abolition of vertigo and positional nystagmus in 85.19% of the cases (n=92; 95%CI: 77.06% to 91.29%), an effect observed in a retest performed after 1 hour. The result was satisfactory after the first maneuver for all cases diagnosed with left side BPPV (n=30) and 79.49% of cases with right side BPPV (n=62) (Table 2).

Table 2 - Symptoms in side-related results observed in the first retest of the maneuver (n=108). Pearson chi2(1) = 7.2241 Pr = 0.007. Fisher's exact = 0.005. 1-sided Fisher's exact = 0.003.

Affected side	Negative Test		Positive Test		Total	
	n	%	n	%	N	%
Right	62	79.49	16	20.51	78	100.00
Left	30	100.00	0	0.00	30	100.00
Total	92	85.19	16	14.81	108	100.00

Source: Authors.

After the second application of the maneuver (in cases where the first maneuver did not cause the abolition of nystagmus and positional vertigo), other 10 subjects obtained a favorable result with the abolition of nystagmus and positional vertigo, resulting in 94.44% (n=102) of the sample observed in retest after 2 hours (table 3).

Table 3 - Retest performed 1 hour after the second maneuver (n=108).

Second Retest	n	%	Cum,
Negative Test	10	9.26	9.26
Positive Test	6	5.56	14.81
Not Performed	92	85.19	100.00
Total	108	100.00	

Source: Authors.

In the one-week follow-up, the recurrence of nystagmus and vertigo in 2 cases was observed during the retest, both had a good response to the post-one maneuver during the first stage. In the total sample, 92.59% presented absence of nystagmus and positional vertigo one week after the maneuver application.

In the present study, 54 patients (50% of the total sample) presented residual dizziness after the successful maneuver. In 24 (22.22%) residual dizziness lasted one day, in 18 (16.67%) residual dizziness lasted two days, in 8 (7.41%) residual dizziness lasted three days and in 4 (3.7%) residual dizziness lasted four days. Of the patients with residual dizziness 81.48% were older than 50 years (Table 4).

Table 4 - Estimated proportion of residual dizziness after successful maneuver (n=100). CI = Confidence Interval.

Residual Dizziness	Proportion	Std. Err.	95% CI	
absent	.46	.0500908	36.34	55.97
1 day	.24	.0429235	16.52	33.50
2 days	.18	.1155339	11.55	26.95
3 days	.08	.0400242	4.00	15.35
4 days	.04	.0148364	1.48	10.34

Source: Authors.

4. Discussion

Vertigo and dizziness are common symptoms in the general population. At least 15% of all patients who complain of vertigo are diagnosed with BPPV. Due to the in-creased incidence and prevalence of BPPV, a large number of studies have been conducted internationally on the efficacy of several treatment maneuvers (Strupp et al., 2020).

In our sample, we observed that in 72.22% of the cases the PC BPPV affected the right side and in 27.77% affected the left side.

The present study obtained a success rate (abolition of nystagmus and positional vertigo) in 85.19% of patients after a single application of the new maneuver presented and in a further 9.26% after two maneuvers, totaling 94.44% success rate with 1 or 2 maneuvers performed on the same day with an interval of 1 hour between them. These findings are in agreement with previous studies (Epley, 1992; Semont et al., 1988; Ganança et al., 2007; Sinsamutpadung & Kulthaveesup, 2021).

The Liberatory Maneuver of Semont [8] was effective to eliminate nystagmus and po-sitional vertigo in 84% of patients after a single maneuver and in 9% of patients after 2 maneuvers, totaling 93% success after 1 or 2 maneuvers. However, other studies were unable to reproduce the same results. Resolution of vertigo and positional nystagmus with a single maneuver was achieved in 70% of patients in the study by Herdman et al. (1993), in 63% of the cases in the study of Gans and Harrington-Gans (2002) and in 48% of the cases in the study by Strupp et al. (2021).

In the original study published by Epley (1992), six of the 30 patients with posterior semicircular canalitiasis required more than one repositioning maneuver to achieve the initial result (absence of vertigo and positional nystagmus). Therefore, the absence of nystagmus and positional vertigo was achieved in 24 patients (80%) with a single maneuver and in 6 (totaling 100% of the sample) with two or more maneuvers. Herdman et al. (1992) reported 57% success in 30 patients with a single Epley maneuver. Gans and Harring-ton-Gans (2002) reported 76% success in 161 patients with a single Epley Maneuver, and their result was 92% for the same group of patients after a second maneuver. This rate was lower than those found in the present study. Other researchers reported a success rate of 86.11% of patients after a single Epley maneuver, however, the reassessment was performed 3 days after the procedure (Lapenna et al. 2021).

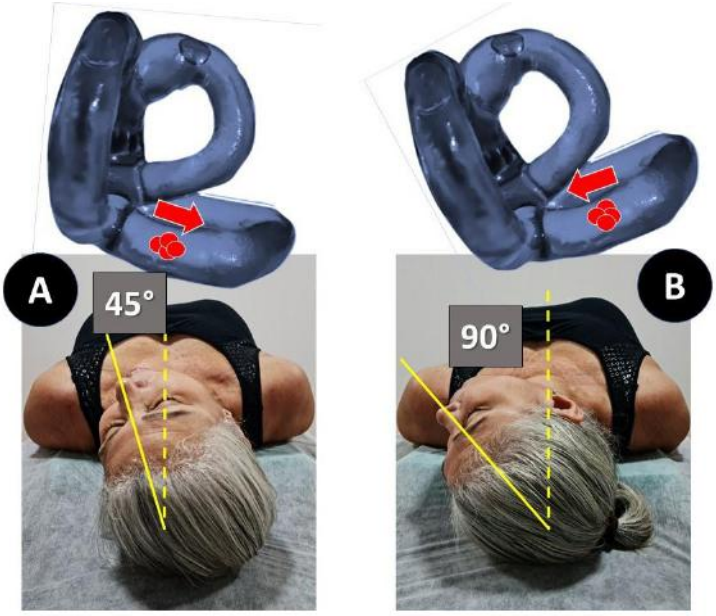
Comparing the new maneuver described in this study and the Epley Maneuver, there are two differences in relation to the position of the semicircular canals. When the head is turned to the unaffected side in supine position, Epley (1992) proposed a 90° angle towards the unaffected side, while the new maneuver described, suggests an additional turning of 90° totaling 135° from step I. This 135° head turn could bring the particles closer the crus commune facilitating the exit in step III. Another difference is in the position of the head while sitting. In the new maneuver described, the patient tilts the head down and rotates 45° to the affected side. This position aligns the non-ampolar arm of the posterior canal with the gravity vector, which could facilitate the movement of the otoconia towards the utricle.

A study using 3D image reconstruction of the semicircular canals (fifteen skull specimens, containing 30 temporal bone specimens) after Micro-CT scanning found the following data in relation to the angle in the plane of the posterior canal: frankfurt plane was 71.54 ± 6.51, sagittal plane was 53.77 ± 5.36, and the coronal plane was 43.33 ± 3.56. Angles between posterior canal and the sagittal plane of skulls had an adverse effect on Epley maneuver (through 3D analysis), when it was less than 45°. So the semicircular angles variation at different degrees was presumed, which might affect the efficacy of the Epley maneuver. After analyzing the Epley maneuver procedure with a 3D reconstructed model in different semicircular angles specimens, the 4th step of the Epley maneuver was affected by the variation of semicircular angles between PC and the sagittal plane of the skull, which led unsuccessful rotation of for otolith. Under this situation, the otolith wouldn't be able to be moved towards the common cruse as expectation, but stocked in the apex of posterior canal. When > 45°, the otolith would slide towards the common cruse by the force of gravity and rotation in the 4th step, which was in keeping with the expectation

of the Epley maneuver. When <45°, the apex of the posterior canal would be lower than the common cruse, so the otolith in posterior canal apex couldn't slide to the common cruse as expected (Tang et al., 2020).

We hypothesized that the new maneuver proposed in this study could compensate the angle < 45° between the posterior canal and the sagittal plane (Figure 2) due to head rotation towards the unaffected side greater than 45° (in relation to the central position - dotted line).

Figure 2 - Representation referring to the right posterior canal BPPV when the angle between the PC and the sagittal plane is <45°. In the Epley Maneuver (A) when the head turns to the opposite side (in dorsal decubitus) the particles can move away from the crus commune (red arrow) leading to failure of the maneuver as proposed by Tang et al., (2019). In the new maneuver proposed in this study (B), this angle <45° could be compensated by a greater turn of the head (approximately 90°) towards the unaffected side during the maneuver, which could lead to displacement towards the crus commune (red arrow), facilitating the exit for the utricle in the next step.



Source: Authors. Centro de Audiologia e Pesquisa em Equilíbrio – CAPE (2023), Brazil.

In a previous study, the 181 middle-aged and elderly patients with PC BPPV, 88 (48.62%) presented residual dizziness after the repositioning maneuver and 93 (51.38%) did not have residual dizziness after the procedure. Residual dizziness may be characterized as instability, dizziness, or disorientation. Age, moderate to severe dizziness and moderate to severe anxiety were independently associated with residual dizziness (Fu et al., 2022).

In the present study, 54 patients (50% of the total sample) presented residual dizziness after the successful maneuver. In 24 (22.22%) residual dizziness lasted one day, in 18 (16.67%) residual dizziness lasted two days, in 8 (7.41%) residual dizziness lasted 3 days and in 4 (3.7%) residual dizziness lasted 4 days. 81.48% of patients with residual dizziness were older than 50 years.

5. Conclusion

The new maneuver studied eliminated nystagmus and positional vertigo in most patients with PC BPPV due to canalithiasis included in this study. It may be preferred for patients who have difficulties in performing maneuvers that involve changing body position on the narrow stretcher and the execution of the lateral decubitus position, such as the obese, the

elderly, patients with neurological alterations, people with orthopedic restrictions or due to some surgery. However, further controlled studies are needed to evaluate the efficacy of this maneuver.

Institutional Review Board Statement

This study was approved by the Research Ethics Committee of the Instituto Nacional de Educação de Surdos - INES, Rio de Janeiro (CAAE: 63837622.0.0000.8137, number: 5.701.744) and it was conducted in accordance with the Principles of Ethics for Medical Research Involving Human Subjects.

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

Data Availability Statement

The data presented in this study are available on request from the corresponding author.

References

Bhattacharyya N., Gubbels S. P, Schwartz S. R., Edlow J. A., El-Kashlan H., Fife T, Holmberg J. M., Mahoney K., Hollingsworth D. B., Roberts R., Seidman M. D., Steiner R. W., Do B. T., Voelker C. C., Waguespack R. W., & Corrigan M. D. (2017) Clinical Practice Guideline: Benign Paroxysmal Positional Vertigo (Update). *Otolaryngol Head Neck Surg.* 156(3_suppl):S1-S47. 10.1177/0194599816689667.

Chang T. P, Lin Y. W, Sung P. Y, Chuang H. Y, Chung H. Y, & Liao W. L. (2016). Benign Paroxysmal Positional Vertigo after Dental Procedures: A Population-Based Case-Control Study. *PLoS One.* 11(4):e0153092. 10.1371/journal.pone.0153092.

Epley J. M. (1992). The canalith repositioning procedure: for treatment of benign paroxysmal positional vertigo. *Otolaryngol Head Neck Surg.* Sep;107(3):399-404. 10.1177/019459989210700310.

Fu W., He F., Bai Y., An X., Shi Y., Han J., & Wang X. (2022). Risk Factors of Residual Dizziness After Successful Treatment for Benign Paroxysmal Positional Vertigo in Middle-Aged and Older Adults. *Front Neurol.* 13:850088. 10.3389/fmed.2021.654637.

Ganança, C. F., Caovilla, H. H., Gazzola, J. M., Ganança, M. M., & Ganança, F. F. (2007). Manobra de Epley na vertigem posicional paroxística benigna associada à doença de Ménière. *Revista Brasileira De Otorrinolaringologia*, 73(4), 506–512. https://doi.org/10.1590/S0034-72992007000400009

Gans R, & Harrington-Gans P. (2002) Treatment efficacy of benign paroxysmal positional vertigo (BPPV) with canalith repositioning maneuver and Semont Liberatory Maneuver in 376 patients. *Semin Hear* 23:129–142. 10.3766/jaaa.17.8.6.

Herdman S., Tusa R., Zee D., Proctor L., & Mattox D. (1993) Single treatment approaches to benign paroxysmal positional vertigo. *Arch Otolaryngol Head Neck Surg* 119:450–454. 10.1001/ARCHOTOL.1993.01880160098015

Imai T., Takeda N., Ikezono T., Shigeno K., Asai M., Watanabe Y., & Suzuki M. (2017). Committee for Standards in Diagnosis of Japan Society for Equilibrium Research. Classification, diagnostic criteria and management of benign paroxysmal positional vertigo. *Auris Nasus Larynx.* 44(1):1-6. 10.1016/j.anl.2016.03.013.

Instrum R. S., & Parnes L. S. (2019). Benign Paroxysmal Positional Vertigo. *Adv Otorhinolaryngol.* 82:67-76. 10.1159/000490273.

Kaur J, & Shamanna K. (2017). Management of benign paroxysmal positional vertigo: a comparative study between epleys manouvre and betahistine. *Int Tinnitus J.* 21:30-4. 10.5935/0946-5448.20170007.

Kim H. J., Park J., & Kim J. S. (2021). Update on benign paroxysmal positional vertigo. J Neurol. 2021 May;268(5):1995-2000. 10.1007/s00415-020-10314-7. *Erratum in: J Neurol*. 10.1007/s00415-020-10314-7

Lapenna R., Faralli M., Cipriani L., Marcelli V., & Ricci G. (2021). Efficacy of Epley's canalith repositioning procedure according to the number of repetitions in the same session: comparison of three protocols. *Acta Otolaryngol*. 141(6):599-602. 10.1080/00016489.2021.1912387.

Lou Y., Cai M., Xu L., Wang Y, Zhuang L., & Liu X. (2020). Efficacy of BPPV diagnosis and treatment system for benign paroxysmal positional vertigo. *Am J Otolaryngol.* 41(3):102412. 10.1016/j.amjoto.2020.102412.

Mandalà M., Salerni L., & Nuti D. (2019). Benign Positional Paroxysmal Vertigo Treatment: a Practical Update. *Curr Treat Options Neurol.* 21(12):66. 10.1007/s11940-019-0606-x.

Maslovara S, Butkovic Soldo S, Sestak A, Milinkovic K, Rogic-Namacinski J, & Soldo A. (2018). 25 (OH) D3 levels, incidence and recurrence of different clinical forms of BPPV. *Braz J Otorhinolaryngol.* 84:453-9. doi.org/10.1016/j.bjorl.2017.05.007

Power L, Murray K, & Szmulewicz D J. (2020). Characteristics of assessment and treatment in Benign Paroxysmal Positional Vertigo (BPPV). *J Vestib Res.* ;30(1):55-62. 10.3233/VES-190687.

Semont A., Freyss G., & Vitte E. (1988) Curing the BPPV with a liberatory maneuver. *Adv Otorhinolaryngol* 42:290–293. 10.1159/000416126.

Sinsamutpadung C., & Kulthaveesup A. (2021). Comparison of outcomes of the Epley and Semont maneuvers in posterior canal BPPV: A randomized controlled trial. *Laryngoscope Investig Otolaryngol.* 6(4):866-871. 10.1002/lio2.619.

Strupp M., Dlugaiczyk J., Ertl-Wagner B. B., Rujescu D., Westhofen M., & Dieterich M. (2020). Vestibular Disorders. *Dtsch Arztebl Int.* 117(17):300-310. 10.3238/arztebl.2020.0300.

Strupp M, Goldschagg N, Vinck A S, Bayer O, Vandenbroeck S, Salerni L, Hennig A, Obrist D, & Mandalà M. (2021). BPPV: Comparison of the SémontPLUS With the Sémont Maneuver: A Prospective Randomized Trial. *Front Neurol.* 12:652573. 10.3389/fneur.2021.652573

Tang X., Tang J., Gong L., Ke R., Tan S., & Tang A. (2020). Adverse effects of semicircular circle angles variation on Epley repositioning procedure: a study on reconstruction of Micro-CT images 3D. *Acta Otolaryngol.* 140(2):99-104. 10.1080/00016489.2019.1699953

Yao Q., Wang H., Song Q., Shi H., & Yu D. (2018). Use of the Bárány Society criteria to diagnose benign paroxysmal positional vertigo. *J Vestib Res.* 28(5-6):379-384. 10.3233/VES-190648.