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ORIGINAL ARTICLE

Effectiveness of Brandt Daroff, Semont and Epley maneuvers in the treatment of Benign Paroxysmal Positional Vertigo: A Randomized Controlled Clinical Trial

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Abstract The aim was to compare the effectiveness of Brandt-Daroff, Semont and Epley maneuver in BPPV resolution. A Single Blind RCT in a Secondary Care Center was performed. Inclusion criteria were: patients with unilateral rotatory nystagmus on Dix-Hallpike Maneuver (DHM). Exclusion criteria: other causes of peripheral or central vertigo. Patients were randomized into 4 groups: Brandt-Daroff, "sham", Semont and Epley. Patients underwent allocation, 1st visit (at 1 week with reprise of original maneuver if persistent nystagmus) and 2nd visit (2 to 4 weeks) with repetitions of both DHM and DHI. Main Outcome Measures: Absence of nystagmus on DHM at 1st and 2nd visit evaluations and DHI score. Resolution was defined as the abscence of nystagmus. We included 34 patients (25 females, 9 males). Patients were randomized to Brandt-Daroff (n = 9), "sham" (n = 7), Semont (n = 9) and Epley (n = 9) group. Overall mean age was 59.85 years (SD ± 13.10). A total of 47.06% patients (n = 16) had negative DHM at 1st visit. Resolution for Brandt-Daroff was 22.22%, "sham" 28.57%, Semont 44.44% and Epley 88.88% (p = 0.024); at 2nd visit follow up, Epley achieved 100% resolution (other maneuvers: 42.86%, 16.67%, 44.44%, respectively. P = 0.006). The DHI improvement at 2nd visit for Brandt-Daroff was 21.17 points, "sham" 8.05, Semont 14.67 and Epley 61.78 (p = 0.001). Epley maneuver was superior to Brandt Daroff, "sham" and Semont maneuvers on nystagmus resolution and DHI improvement in patients with BPPV.

Keywords Benign Paroxysmal Positional Vertigo · Epley maneuver · Semont maneuver · Brandt-Daroff exercises · Placebo · Randomized controlled trial

Introduction

Benign Paroxysmal Positional Vertigo (BPPV) is one of the most common causes of vertigo in patients with vestibular disorders [1] and also, the most common cause of peripheral vertigo [2]. BPPV was first described by Barany (1923) [2] but it was until 1952 when Margaret Dix and Charles Hallpike created the diagnostic test named after them [3]. Dix-Hallpike Maneuver (DHM) is nowadays considered the gold standard for diagnosis. The incidence of BPPV estimated is 64/100,000 per year, with an annual prevalence of 2.4% [4]. BPPV is characterized by rotatory dizziness symptoms according to postural changes of the head, such as side-lying or turning head to left or right [1]. The etiology of BPPV is explained by two theories: cupulolithiasis, in which the adhesion of otoliths to the cupula in any of the three semicircular canals makes it denser than the endolymphatic flow and, as a result, more susceptible to gravity effects. Canalithiasis on the other hand is the free-floating otoconia in the semicircular canals. These otoconia, stimulate the ampullary crests,

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establishing a rotatory feeling dependent on the postural head movement related to gravity. Among the three semicircular canals, the posterior semicircular canal is the most affected (80%), and the superior canal the less frequently implicated [5–7].

Positional nystagmus is the most important finding for BPPV diagnosis. Through the characteristics of nystagmus it is possible to identify the semicircular canal involved, allowing also to distinguish between cupulolithiasis or canalithiasis and thus selecting the most appropriate treatment [7]. Posterior semicircular canal nystagmus has a torsional component (clockwise or counter-clockwise) associated with a superior vertical element that persists for less than one minute [8].

Classic eye movements within Dix-Hallpike Maneuver, suggestive clinical history and the absence of another related pathology integrate the diagnosis of BPPV [9]. If the patient has no presence of nystagmus on Dix-Hallpike Maneuver, it is recommended to perform the Roll-Test maneuver in search for lateral canal BPPV.

Diverse maneuvers based on cupulolithiasis and canalithiasis theories have been proposed as treatment for BPPV, the more relevant are Brandt-Daroff, Semont and Epley, the last one being the most widely used [8]. The purpose of these maneuvers is to return otoconia particles from the involved canal back to the utricular macula with symptom resolution [10]. Nevertheless, there are still numerous publications in search for the best maneuver. The ideal maneuver would have a prompt BPPV resolution and less BPPV recurrences.

Because of the subjective symptomatology and the intricacy to quantify the improvement after the implemented therapy on patients with vertigo, Jacobson and Newman in 1990 [11] developed a tool named Dizziness Handicap Inventory (DHI) with 25 questions divided into three domains: emotional (9 items), functional (9 items) and physical (7 items). The minimum score is 0 and the maximum score is 100. Since the creation of this tool, it has been widely accepted, used on multiple vertigo and dizziness related studies and validated in more than 17 languages [12].

The purpose of this article was to measure the efficacy of the different Particle Repositioning Maneuvers (PRM) as the treatment for posterior canal BPPV, assessed through resolution of nystagmus on Dix-Hallpike Maneuver as well as improvement on the DHI score.

Methods

Type of study

Single Blind, Randomized Controlled Clinical Trial.

Subjects

Patients with BPPV diagnosis performed through Dix-Hallpike Maneuver, with no previous treatment, who attended the Otorhinolaryngology and Head and Neck Surgery service from March 2013 to February 2014.

Ethical Approval

The protocol was approved by the Ethics Committee of this institution with registry number of 0126, and was in accordance to the Helsinki Declaration. Each participant provided individual informed consent.

Inclusion Criteria

There was no age or gender restriction. The principal requirement for inclusion was diagnosis of posterior canal BPPV, with positive nystagmus (up beating and torsional) on the DHM.

Exclusion Criteria

Patients were excluded if central vertigo or other causes of peripheral vertigo were suspected (for example: Meniere disease, vestibular neuritis). Patients with previous brain or cervical injury, recent medical treatment (vestibular suppressants) or refusal to sign the informed consent.

Elimination Criteria

Failure to attend to the first visit follow up after the allocation visit.

Study Procedure

Patients were randomized into 4 groups through a computerized system and were assigned the therapeutic maneuver. With randomization complete, demographic and clinical data were obtained. Only one maneuver was performed for each visit.

In the Brandt-Daroff group, exercises were performed as originally described [13] with 30 min sessions each day. “Sham maneuver”represented the placebo group, the clinician performed a Semont maneuver but to the non affected contralateral side.

There were two visits after allocation: first visit (1 week) and second visit (from two to four weeks). After 2nd visit and end of study, patients were treated according to their clinician best decision.

Outcome Measurements

Absence of nystagmus was assessed during the 1st and 2nd visit. The primary outcome measurement was the presence or abscence of nystagmus, evaluated on the Dix-Hallpike Maneuver (negative or positive). Resolution was defined as the abscence of nystagmus. Recurrence was defined as negative nystagmus on the 1st visit and positive nystagmus on the 2nd visit.

Study Instrument

The Dizziness Handicap Inventory (DHI) [14] was applied for subjective evaluation of vertigo in the allocation evaluation and the 2nd visit. We considered reduction of symptoms if these categories were improved (with a decrement in score) from allocation to 2nd visit.

Blinding

This study was blinded to the participants only. Patients in the placebo group received a sham maneuver to the contralateral side, therefore, patients were not aware of not receiving any effective treatment for their BPPV. Nevertheless, they knew the possibilities of the different maneuvers in this study and the probability of not receiving any effective maneuver at all.

Statistical Analysis

Descriptive statistic with central tendency measures and data dispersion through mean and standard deviation were used in case of continuous variables and frequency and proportions in case of categorical variables. The comparison between groups was performed with one-way analysis of variance (ANOVA) for continuous variables and X^2 and Fisher's exact test for categorical variables. A $p \leq 0.05$ was considered as statistically significant.

The collected data was introduced in the Statistical Package for the Social Sciences (SPSS) version 21 (IBM Corp., Armonk, NY, USA) for its statistical analysis.

Results

One hundred and seventy-three patients were assessed for eligibility, but only 38 were randomized. In order to see the enrollment process see Fig. 1. Participants were randomized into four groups: Brandt-Daroff (n = 10), "sham" (n = 8), Semont (n = 9) and Epley (n = 11). Four patients were lost to follow up after allocation and were eliminated. After applying elimination criteria, the groups were as follow: Brandt-Daroff (n = 9), "sham" (n = 7), Semont (n = 9) and Epley (n = 9). All patients were considered for the intention to treat analysis.

From these 34 participants, 73.50% (n = 25) were females, 26.50% (n = 9). Overall mean age was 59.85 years (SD ± 13.10), range from 34 to 83 years. The comorbidities found in this study were: diabetes mellitus 14.70% (n = 5), hypertension 38.20% (n = 13), dyslipidemia 11.80% (n = 4), hypothyroidism 5.90% (n = 2) and prolonged rest in 17.60% (n = 6). There was no clinical history of hyperthyroidism in our population. None of these clinical variables were statistically significant between groups. Demographic and clinical characteristics of the population are depicted on Table 1.

The DHM for right posterior canal was positive in 70.60% (n = 24) and left posterior canal in 29.40% (n = 10). Mean latency duration was of 5.41 ± 5.81 s (range 1 to 35 s). Nystagmus mean duration was 10.5 ± 3.75 s (range 5 to 20 s).

Resolution Rates

Global 1st visit resolution rate (absence of nystagmus) in our population was 47.06% (n = 16). Resolution rate of Epley maneuver (88.8%) was superior when compared to Brandt-Daroff (22.2%), "sham" (28.5%) and Semont maneuver (44.4%) ($p = 0.024$), as displayed on Table 2.

Data analyzed with X^2 test at 1st visit follow up confirmed Epley superiority against Brandt-Daroff exercises ($p = 0.004$), "sham" ($p = 0.013$) and Semont maneuver ($p = 0.046$).

Twenty-nine patients received a 2nd visit evaluation. The resolution rate of BPPV was 51.72% (n = 15) with the original maneuver assigned. Epley maneuver was superior on the resolution of nystagmus compared to Brandt-Daroff exercises (100% vs 42.86%), "sham" (100% vs 16.67%) and Semont maneuver (100% vs 44.4%) ($p = 0.006$). See Fig. 2.

When comparing Epley to each of the other maneuvers, these outcomes remained significant at the 2nd visit follow up, with Epley being superior in the resolution rate (Brandt-Daroff $p = 0.018$, "sham" $p = 0.002$, Semont $p = 0.017$).

Intention to Treat Analysis

Additionally, two intention to treat analysis were performed considering the four patients lost after allocation and the five patients lost after 1st visit. *First scenario*: all nine patients (four patients lost after allocation and five patients lost after 1st visit) were considered to have positive nystagmus at 2nd visit. In this scenario Epley was superior only against "sham" [Brandt-Daroff (70% vs 30%; $p = 0.074$), "sham" (70% vs 12%; $p = 0.015$),

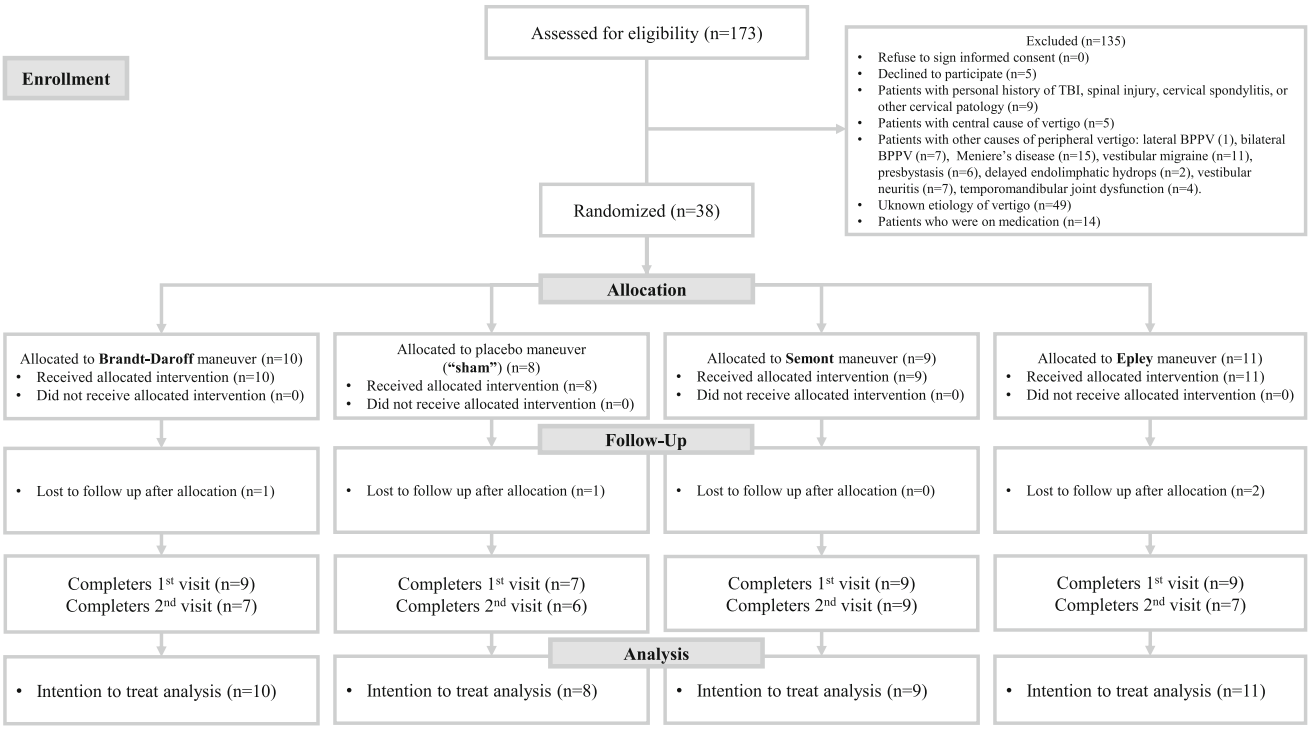

Fig. 1 Consort flow diagram

Table 1 Demographic and clinical characteristics of the population

	Total	Brandt-Daroff group (n = 9)	"Sham" group (n = 7)	Semont group (n = 9)	Epley group (n = 9)	*p* Value
Age (mean, SD, years)	59.85 ± 13.10	59.66	55.28	64.66	58.77	0.600
Gender	M = 9	M = 3 (33.33%)	M = 1 (14.28%)	M = 1 (11.11%)	M = 4 (44.44%)	0.343
	F = 25	F = 6 (66.66%)	F = 6 (85.71%)	F = 8 (88.88%)	F = 5 (55.55%)	0.898
Diabetes mellitus	5	1 (11.11%)	1 (14.28%)	2 (22.22%)	1 (11.11%)	0.898
Hypertension	13	4 (44.44%)	3 (42.85%)	4 (44.44%)	2 (22.22%)	0.721
Dyslipidemia	4	0 (0%)	0 (0%)	3 (33.33%)	1 (11.11%)	0.104
Hypothyroidism	2	2 (22.22%)	0 (0%)	0 (0%)	0 (0%)	0.116
Prolonged rest	6	2 (22.22%)	1 (14.28%)	0 (0%)	3 (33.33%)	0.303
Affected	R = 24	R = 7 (77.77%)	R = 6 (85.71%)	R = 6 (66.66%)	R = 5 (55.55%)	0.564
ear-side	L = 10	L = 2 (22.22%)	L = 1 (11.11%)	L = 3 (33.33%)	L = 4 (44.44%)	
Nystagmus latency (mean, SD, seconds)	5.41 s ± 5.81 s	4.55 s	3.14 s	8.44 s	5 s	0.204
Nystagmus duration (mean, SD, seconds)	10.5 s ± 3.75 s	8.88 s	11.14 s	11.11 s	11 s	0.715

M: Males, F: Females, R: Right, L: Left, CW: Clockwise, CCW: Counter-clockwise, **s**: Seconds

Semont (70% vs 40%; $p = 0.178$)]. *Second scenario*: all nine patients were considered to have negative nystagmus at 2nd visit, in this situation Epley was statistically significant superior compared to all other maneuvers [Brandt-Daroff (100% vs 60%; $p = 0.025$), "sham" (100% vs 37%; $p = 0.003$), Semont (100% vs 50%; $p = 0.010$).

Table 2 Success rate of original maneuver assigned

	Brandt-Daroff group (n = 9)	"Sham" group (n = 7)	Semont group (n = 9)	Epley group (n = 9)	*p* Value[a]
1st visit follow up					**0.024**
Positive nystagmus (n, %)	7 (77.77%)	5 (71.42%)	5 (55.55%)	1 (11.11%)	
Negative nystagmus (n, %)	2 (22.22%)	2 (28.57%)	4 (44.44%)	8 (88.88%)	
Recurrence (n, %)	–	–	–	–	
Lost to follow-up (n)	–	–	–	–	
Total (n)	9	7	9	9	
2nd visit follow up					**0.006**
Positive nystagmus (n, %)	4 (57.14%)	5 (83.33%)	5 (55.56%)	0 (0%)	
Negative nystagmus (n, %)	3 (42.86%)	1 (16.67%)	4 (44.44%)	7 (100%)	
Recurrence (n, %)	0 (0%)	0 (0%)	1 (11.11%)	0 (0%)	
Lost to follow-up (n)	2	1	0	2	
Total (n)	9	7	9	9	

[a]Fisher test

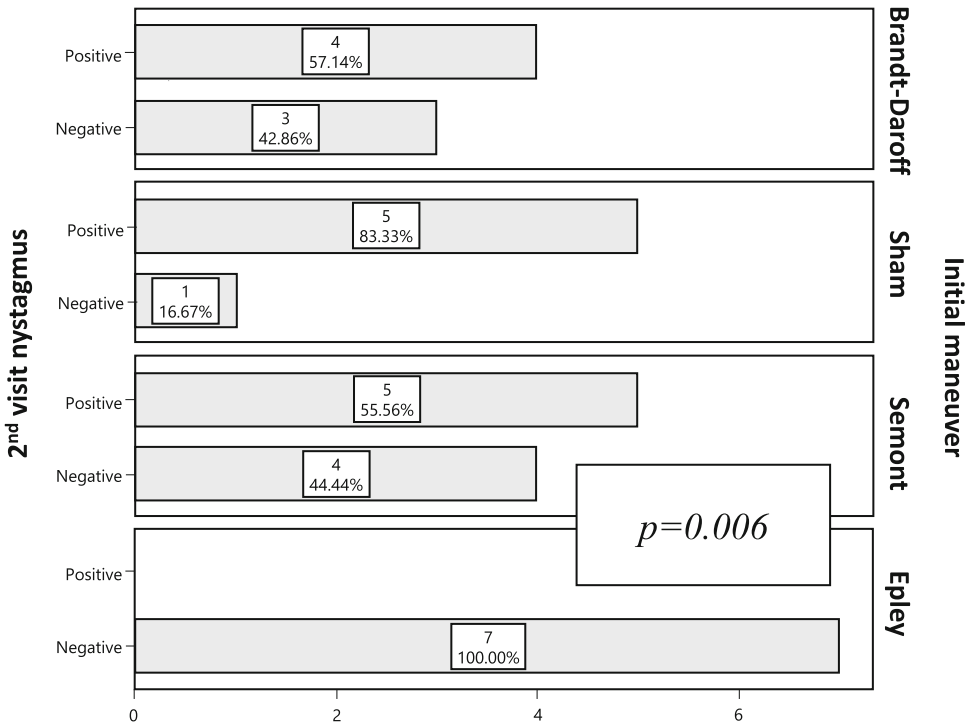

Fig. 2 Nystagmus resolution on dix-hallpike maneuver: 2nd visit follow up

A *third scenario* of intention to treat analysis was calculated considering only the five patients lost after 1st visit. In this scenario the last evaluation at 1st week (DHM, nystagmus present or absent) was assumed to persist at the second visit. In this manner, Epley was superior to all other maneuvers [Brandt-Daroff (100% vs 33%; $p = 0.009$), "sham" (100% vs 28%; $p = 0.005$), Semont (100% vs 44%; $p = 0.029$)].

The five patients lost to follow up after 1st visit patients were contacted by a phone call and 3 patients declared improvement (1 patient from "sham" group and 2 from Epley group). One patient moved to another city (1 from Brandt-Daroff group) and the fifth subject declined to continue in the study (1 from Brandt-Daroff group).

Dizziness Handicap Inventory

Total basal DHI score was 52.82 (SD ± 25.47) points. At 2nd visit evaluation only 28 patients completed the DHI, and the total 2nd visit mean score was 26.85 (SD ± 29.43).

Table 3 Dizzines handicap inventory (Dhi) score improvement At Basal and 2nd visit follow up

	Brandt-Daroff group (n = 9)	"Sham" group (n = 7)	Semont group (n = 9)	Epley group (n = 9)	*p* Value[&]
Basal DHI (n = 34)	56.88	41.71	47.11	63.11	0.334
2nd visit DHI (n = 28)	35.71	33.66	32.44	1.33	0.116
Improvement (difference between 2nd visit and basal DHI score, %)	− 21.17, 37.21%	− 8.05, 19.29%	− 14.67, 31.13%	− 61.78, 97.89%	< 0.001

[&]ANOVA Analysis (Analysis of variance). DHI: Dizziness Handicap Inventory

DHI improvement at 2nd visit was 21.17 points for Brandt-Daroff, 8.05 for "sham", 14.67 for Semont and 61.78 for Epley ($p < 0.001$) as evidenced on Table 3.

ANOVA analysis was non significant on total score of second week DHI (p = 0.116) among the different treatment groups.

Recurrences

Only 1 patient of the Semont group had recurrent nystagmus at 2nd visit follow up, the patient was treated successfully with repetition of original Semont maneuver.

Discussion

We report a randomized controlled clinical trial that proves the effectiveness of the Epley maneuver. This was evident on the patients that completed the study (first and second visit follow up) and also, on the intention to treat analysis.

Fortunately, the majority of BPPV patients are resolved with otoconia particle repositioning maneuvers. Nevertheless, there are on the literature controversial results on the effectivity of these diverse maneuvers. Questions such as which maneuver has the least recurrences, or which has the most rapid improvement, both objectively and subjectively, are not adequately answered, there is still a need for RCTs. Our study adds on this scientific background and answers these vital questions.

Hilton and Pinder [15], on a Cochrane systematic review, described the effectiveness of the Epley maneuver. This last study included 11 different studies with a total of 745 patients and concluded that Epley maneuver was more effective for BPPV resolution compared to the control group, "sham" maneuver and Brandt-Daroff exercises, but additionally described a similar effectivity to Semont and Gans maneuvers.

Our present study shows superior effectivity of the Epley maneuver in vertigo control and nystagmus resolution on the 1st visit if compared to Brandt-Daroff group (88.88% vs 22.22%, $p = 0.004$), "sham" group (88.88% vs 28.57%, $p = 0.013$) and the Semont group (88.88% vs 44.44%, $p = 0.046$). On the 2nd visit of our study, we achieved a 100% nystagmus resolution (n = 7) in patients assigned to Epley maneuver, which was statistical significant compared with the rest of the maneuvers (Brandt-Daroff $p = 0.018$, "sham" $p = 0.002$, Semont $p = 0.017$).

Interestingly, a multicentric double-blind study described improvement of the Epley maneuver observed within the first 20 min (63.9%) of the maneuver, in contrast with Semont (37.5%) and placebo (38.7%), and this effect persisted at one week follow up (Epley 94.4%, Semont 71.9% and placebo 71.0%, $p = 0.023$) [16].

Gupta [17], compared effectivity with similar PRMs as our study. This author described improvement in 90% (n = 27) of patients treated with the Epley maneuver immediately after the therapeutic maneuver, in contrast to 73.33% (n = 22) of Semont group and 50% (n = 15) of Brandt-Daroff group. In our study, the absence of nystagmus on the 1st visit in the Semont group and "sham" group were even lower (44.44% and 28.57%, respectively). Our outcomes in nystagmus resolution are similar to Sen [18], who obtained a resolution of 87% on the Epley group (n = 26) and 57% (n = 17) on the Semont group, both groups at first week follow up.

In an article that included two hundred patients by Ajayan [19], an improvement of 84% (n = 84) with the Epley maneuver and 81% (n = 81) for the Semont maneuver was achieved on the first week. At one month-follow up a resolution of 96% and 93% was obtained and in the 3 months-follow up it was 95% and 94% for Epley and Semont maneuvers, respectively. No statistical significance was reached and both maneuvers were considered equally effective. On the other hand, the Semont maneuver required more maneuvers to achieved success ($p = 0.0529$) compared to the Epley. Unfortunately, our study did not

evaluate BPPV resolution in the long term and this needs to be considered as part of our limitations.

In a meta-analysis by Zhang [20], Semont maneuver was superior against the untreated group ($p = < 0.01$) and sham maneuver group ($p = < 0.01$) but not superior to Epley maneuver (RR = 0.83, 95% CI 0.68–1.00, $p = 0.05$) or Brandt-Daroff exercises (RR = 1.32, 95% CI 1.00–1.75, $p = 0.05$). Zhang also described that Semont maneuver recurrence rates were not statistically significant except when compared with the group with no intervention.

According to Benito [21] the effectivity of a unique Epley maneuver up to 7 days was 82% (compared with the 88% obtained in our study). The previously cited author refers a better outcome after 3 months in patients treated with Epley maneuver than patients treated with Semont maneuver.

There is controversy in the literature, between effectiveness of the Epley and Semont maneuvers, furthermore, some authors have reported they are equally effective [6, 15, 19, 22, 23]. Nevertheless, other authors have concluded that the Epley maneuver is superior and requires less maneuver repetitions [16–18, 24, 25].

The main strength of this study is the intention to treat analysis we performed considering various outcomes. Epley was not superior to Brandt-Daroff exercises in the first intention to treat analysis. Nonetheless, Epley superior effectiveness against Semont maneuver was evident on the second scenario (nine patients at 2nd visit as negative nystagmus, $p = 0.010$) and on the third scenario (1st visit nystagmus status assumed to persist in the second visit, $p = 0.029$). Additionally, Epley was statistical significant superior to Semont among the 29 patients that attended the second visit follow up ($p = 0.006$).

The definition of resolution of BPPV in most studies is considered as the absence of nystagmus. However, the impact in quality of life through DHI is rarely evaluated. Our study applied the DHI in an effort to understand the patient subjective symptoms. We have described an improvement on DHI values after treatment of all groups. We only considered total DHI score, according to Van De Wyngaerde, et al. [26] total DHI score is warranty of general dizziness evaluation. Rodrigues, et al. [27] described both subscale and total DHI scores, with the latter outcomes similar to ours. Rodrigues also found that recurrence rates were lower in any PRM performed if concomitant vestibular exercises were associated ($p = 0.023$).

It is important to consider that other authors, such as Sreenivas [28], have found association between diabetes mellitus and BPPV recurrence ($p = 0.015$). Additionally, other authors [29–31] have also demonstrated the association of osteoporosis and BPPV presence.

This single blinded randomized clinical control trial shows a short term follow up superiority of the Epley maneuver against all other maneuvers (Brandt Daroff, Semont and Placebo—"sham"). Furthermore, this study adds on the use of DHI as a form to evaluate the subjective symptoms of BPPV patients. Based on our results we recommend the performance of the Epley maneuver as a primary maneuver on a BPPV patient.

Conclusions

Epley maneuver was superior to Brandt Daroff, "sham" and Semont maneuvers on nystagmus resolution and Dizziness Handicap Inventory improvement in the treatment of patients with BPPV.

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Author's Contributions All authors contributed to the manuscript and are accountable of all aspects of the manuscript.

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Data Availability Available upon request.

Code Availability SPSS was used.

Declarations

Conflict of interest The authors declares that they have no conflict of interests.

Ethics Approval Research and ethical approval was obtained in CIDOCS, number 0126.

Consent to Participate All subjects signed informed consent.

Consent for Publication this study is not considered for publication in any other journal. The submitted work is original and the authors consent to be considered for publication in the indian journal of otolaryngology.

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