Effectiveness of Particle Repositioning Maneuvers in the Treatment of Benign Paroxysmal Positional Vertigo: A Systematic Review

Janet Odry Helminski, David Samuel Zee, Imke Janssen and Timothy Carl Hain

PHYS THER. 2010; 90:663-678.
Originally published online March 25, 2010
doi: 10.2522/ptj.20090071

Effectiveness of Particle Repositioning Maneuvers in the Treatment of Benign Paroxysmal Positional Vertigo: A Systematic Review

Janet Odry Helminski, David Samuel Zee, Imke Janssen, Timothy Carl Hain

Background. Benign paroxysmal positional vertigo (BPPV) is the most common cause of vertigo.

Purpose. The purpose of this systematic review was to determine whether patients diagnosed with posterior canal (PC) BPPV, based on positional testing, and treated with a particle repositioning maneuver will show the resolution of benign paroxysmal positional nystagmus (BPPN) on the Dix-Hallpike Test performed 24 hours or more after treatment.

Data Sources. Data were obtained from an electronic search of the MEDLINE, EMBASE, and CINAHL databases from 1966 through September 2009.

Study Selection. The study topics were randomized controlled trials (RCTs), quasi-RCTs, the diagnosis of PC BPPV, treatment with the particle repositioning maneuver, and outcome measured with a positional test 24 hours or more after treatment.

Data Extraction. Data extracted were study descriptors and the information used to code for effect size.

Data Synthesis. In 2 double-blind RCTs, the odds in favor of the resolution of BPPN were 22 times (95% confidence interval=3.41–141.73) and 37 times (95% confidence interval=8.75–159.22) higher in people receiving the canalith repositioning procedure (CRP) than in people receiving a sham treatment. This finding was supported by the results reported in 8 nonmasked quasi-RCTs. Studies with limited methodological quality suggested that a liberatory maneuver (LM) was more effective than a control intervention; there was no significant difference in the effectiveness of the LM and the effectiveness of the CRP; the self-administered CRP was more effective than the self-administered LM; and the CRP administered together with the self-administered CRP was more effective than the CRP administered alone. The Brandt-Daroff exercises were the least effective self-administered treatments.

Limitations. The limitations included the methodological quality of the studies, the lack of quality-of-life measures, and confounding factors in reporting vertigo.

Conclusions. Randomized controlled trials provided strong evidence that the CRP resolves PC BPPN, and quasi-RCTs suggested that the CRP or the LM performed by a clinician or with proper instruction at home by the patient resolves PC BPPN. There were no data on the effects of the maneuvers on outcomes relevant to patients.

J.O. Helminski, PT, PhD, is Associate Professor, Department of Physical Therapy, Midwestern University, 555 31st St, Downers Grove, IL 60515 (USA). Address all correspondence to Dr Helminski at: jhelmi@midwestern.edu.

D.S. Zee, MD, is Professor, Departments of Neurology, Ophthalmology, Otolaryngology, and Pathology, School of Medicine, The Johns Hopkins University, Baltimore, Maryland.

I. Janssen, PhD, is Assistant Professor, Department of Preventive Medicine, Rush University Medical Center, Chicago, Illinois.

T.C. Hain, MD, is Professor, Departments of Physical Therapy and Human Movement Science, Otolaryngology, and Neurology, Northwestern University Medical School, Chicago, Illinois.

[Helminski JO, Zee DS, Janssen I, Hain TC. Effectiveness of particle repositioning maneuvers in the treatment of benign paroxysmal positional vertigo: a systematic review. *Phys Ther.* 2010;90:663–678.]

Benign paroxysmal positional vertigo (BPPV) is characterized by brief periods of vertigo triggered by a change in the position of a person's head relative to gravity. In the general population, the lifetime prevalence of BPPV is 2.4%, and the 1-year incidence is 0.6%.[1] It is the most common vestibular disorder, accounting for one third of vestibular diagnoses in the general population.[1] Benign paroxysmal positional vertigo can affect the quality of life of elderly patients and is associated with reduced activities of daily living, falls, and depression.[2] Patients with BPPV experience delays in diagnosis and treatment, the mean delay being 92 weeks, and they frequently are inappropriately treated with vestibular suppressant medications.[3]

Benign paroxysmal positional vertigo is caused by abnormal mechanical stimulation of 1 or more of the 3 semicircular canals within the inner ear (Fig. 1). The fluid-filled canals normally act to detect rotation of the head through the deflection of sensory hair cells embedded within a gelatinous membrane, the cupula. The weighted sensory membrane of the maculae normally acts to detect gravitational forces on the head. In BPPV, calcite particles (otoconia), which normally weight this membrane, become dislodged and sediment in the canals, changing the dynamics of the canals. There are 2 primary theories for the mechanism of BPPV. The first is cupulolithiasis,[4] in which the dislodged otoconia directly attach to the cupula, weighting this membrane. Reorientation of the canal relative to gravity deflects the cupula, exciting or inhibiting the ampullary organ. The second is canalithiasis,[5] in which the otoconia freely sediment in the canals. Reorientation of the canals causes the otoconia to move to the lowest part of the canals, creating a drag on the endolymph, resulting in fluid pressure on the cupula, and activating the ampullary organ.

The Dix-Hallpike maneuver,[6] referred to as the Dix-Hallpike Test (DHT) in this article, is the standard from which the diagnosis of posterior canal (PC) BPPV is made and differentiated from other conditions.[7,8] The diagnostic criteria for PC BPPV are vertigo associated with characteristic ocular nystagmus that is torsional (toward the dependent ear) and directed upward, consistent with the excitation of the ampullary organ of the PC[9]; a 1- to 40-second latency before the onset of vertigo and nystagmus[10–12]; and vertigo and nystagmus with a duration of less than 60 seconds.[13] With repeated positioning, PC BPPV temporarily becomes less intense and disappears.[13] For the DHT, the estimated sensitivity and specificity are 79% (95% confidence interval [CI]=65–94) and 75% (CI=33–100), respectively.[14] The interrater reliability for interpreting the direction of eye movement ranges from a mean percentage of agreement of 43% (fair) to a mean percentage of agreement of 81% (substantial), depending on the level of expertise.[15]

Treatment of BPPV

Once the involved canal is identified, BPPV often is treated with particle repositioning maneuvers. These maneuvers move otoconia out of the affected canal and back into the vestibule, where it is thought that the particles dissolve.[16,17]

Historically, the first maneuvers used for BPPV were the Brandt-Daroff exercises,[10] which were designed to habituate symptoms. The patient repeatedly moved from sitting at the edge of the bed to lying on the side (side lying) with the head rotated 45 degrees toward the ceiling. The patient alternated between left side lying and right side lying.

The canalith repositioning procedure (CRP), developed by Epley[18] (Fig. 2A), was designed to use gravity to treat canalithiasis of the PC. The clinician moves the patient through a series of 4 positions. With each position, the otoconia settle to the lowest part of the canal, move around the arc of the PC, and finally deposit in the vestibule. This procedure requires a 180-degree turn of the head[19–21] and a return to a sitting position from lying on the uninvolved side.[21] To enable the otoconia to settle, each position is maintained for at least 30 seconds.[20] Vibration applied to the mastoid process of the involved side does not affect the outcome of the procedure and is no longer considered necessary.[22–24]

The liberatory maneuver, developed by Semont et al[25] (Fig. 2B), was designed to use inertia and gravity to treat cupulolithiasis of the PC. To evacuate the particles, the patient is rapidly swung from lying on the involved side to lying on the uninvolved side through a 180-degree cartwheel motion with a duration of less than 1.3 seconds.[19]

Both the CRP and the liberatory maneuver have been modified to enable a patient to self-treat. With the self-administered CRP,[26,27] the patient moves through the same positions as in the CRP, except that the head is extended over the edge of a pillow. With the self-administered liberatory maneuver,[27] the patient performs the maneuver independently, with

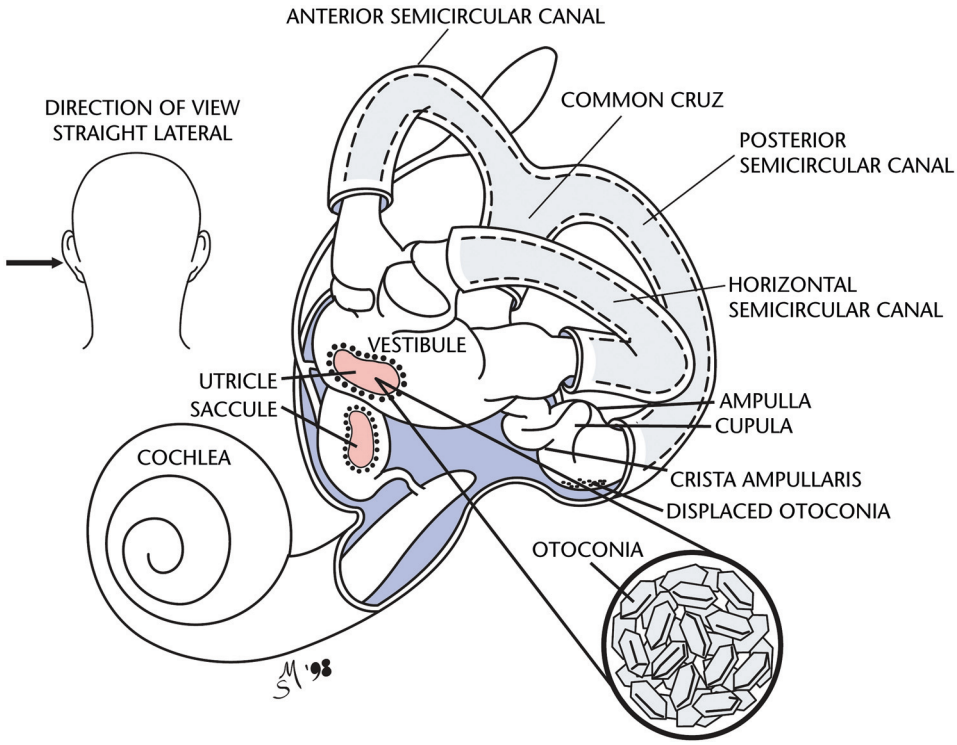

Figure 1.
Mechanisms of benign paroxysmal positional vertigo. Reprinted with permission from American Dizziness and Balance. Copyright 2007.

no other modifications. Both exercises are stopped when the patient has been vertigo free for at least 24 hours.[26,27]

The role of activity restrictions in the outcome of particle repositioning maneuvers remains uncertain. Post-maneuver activity restrictions did not improve the efficacy of treatment with the CRP[28,29] or the liberatory maneuver,[28] but patients with no activity restrictions required 1 or 2 more treatment sessions to achieve a successful outcome.[30]

The DHT is critical for determining the outcome of particle repositioning maneuvers.[7,31] The absence of the characteristic nystagmus indicates the resolution of PC BPPV.[32] The patient's report of vertigo is more variable than the observation of the characteristic nystagmus on positional testing. Patients showing

The Bottom Line

What do we already know about this topic?

Randomized controlled trials (RCTs) suggest that the canalith repositioning procedure (CRP) is more effective than a sham treatment in the resolution of posterior canal benign paroxysmal positional nystagmus (PC BPPN).

What new information does this study offer?

Evidence for the use of other particle repositioning maneuvers is weak due to the limited numbers of studies and no RCTs. There is no significant difference in the effectiveness of the CRP compared with the liberatory maneuver (LM). If properly instructed, self-administered CRP and LM are effective. The Brandt-Daroff habituation exercises are the least effective. The most effective treatment is a combination of the CRP and the self-administered CRP.

If you're a patient, what might these findings mean for you?

The CRP and LM performed by a clinician or, with proper instruction, by the patient at home resolves PC BPPN.

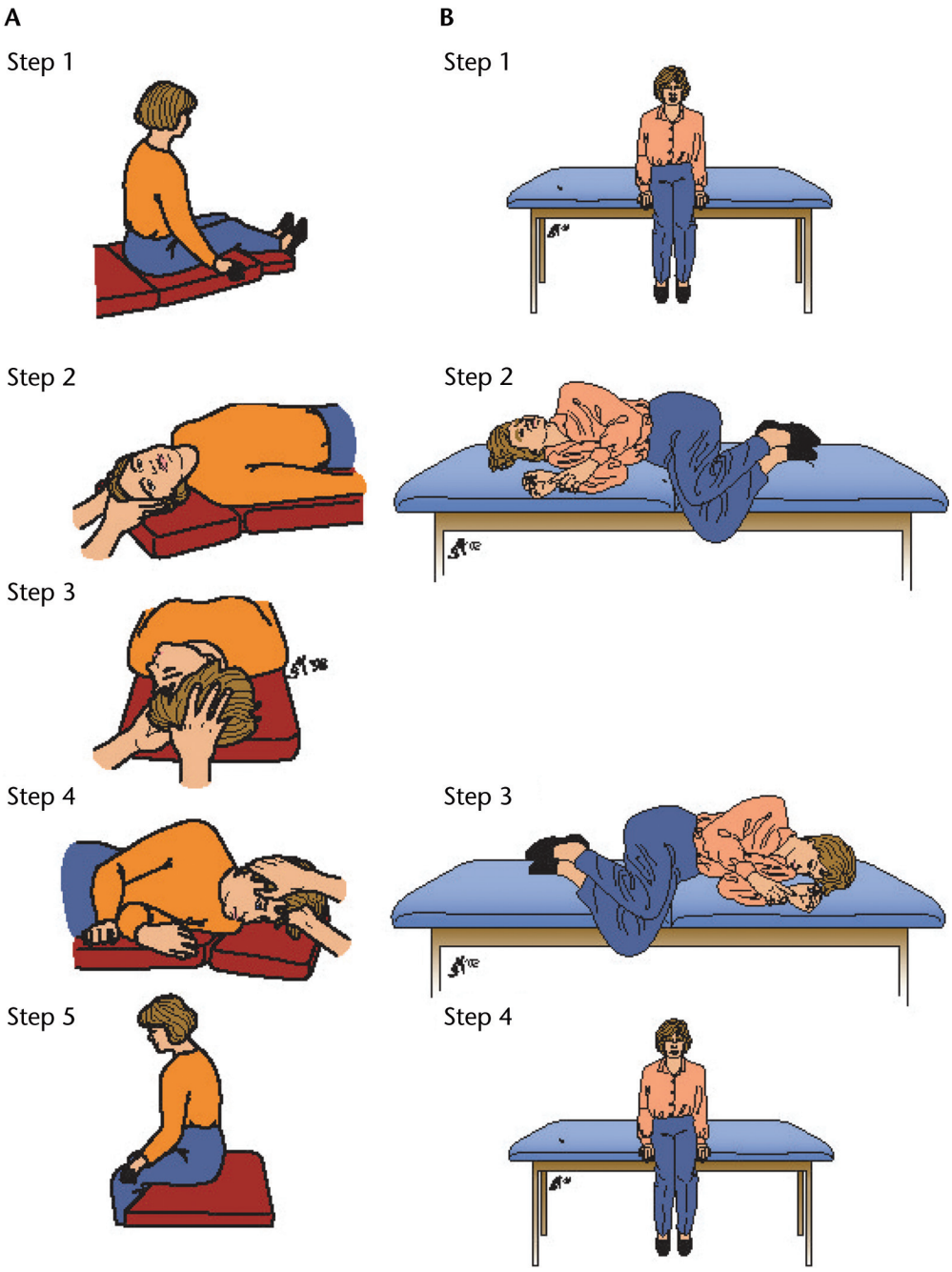

Figure 2.
Particle repositioning maneuvers. (A) Canalith repositioning procedure illustrated for treatment of the right posterior canal. The clinician moves the patient through a series of 4 positions, starting with the placement of the involved canal in the head-hanging position of the Dix-Hallpike Test. To begin, the patient is positioned in the long sitting position (sitting on the treatment table with the legs extended). The patient's head is rotated 45 degrees toward the right. The patient is then lowered into the supine position with the neck extended 20 degrees over the edge of the treatment table; this is the head-hanging position. The head is rotated through 90 degrees of motion, ending in 45 degrees of neck rotation toward the uninvolved side. This step is followed by rolling onto the uninvolved side while maintaining the head-on-trunk position and, finally, sitting up from lying on the uninvolved side. Each position is maintained for a minimum of 30 seconds or as long as the nystagmus lasts. The procedure is repeated 3 times. (B) Liberatory (Semont) maneuver illustrated for treatment of the right posterior canal. The patient sits on the edge of the treatment table. The clinician rapidly moves the patient to lying on the involved side with the head rotated 45 degrees toward the uninvolved side. While maintaining the head-on-trunk position, the clinician swings the patient from lying on the involved side to lying on the uninvolved side. The head then is gently tapped on the treatment table. Each position is maintained for 1.5 minutes. The procedure is repeated 3 times. Reprinted with permission from American Dizziness and Balance. Copyright 2007.

the resolution of positional nystagmus on the DHT may report vertigo if concurrent vestibular deficits exist.[33] Patients with positive findings on the DHT may report no vertigo at the time of follow-up if provoking positions are avoided or if they have unrecognized BPPV (imbalance with no vertigo).[2] Because of these confounding factors, the patient's report of vertigo should not be the only outcome measure.

The time interval between treatment and outcome assessment is critical. To separate the effects of active treatment from a fatigue response, outcome should be assessed 24 hours or more after treatment.[32] Repeated positioning may cause a fatigue response that can mimic successful treatment.[32] Within 7 days of PC BPPV symptom onset, 30% of patients will experience spontaneous remission.[34] To minimize the possibility of spontaneous remission causing a false-negative particle repositioning maneuver outcome and to avoid a fatigue response, outcome ideally should be assessed 24 hours after treatment.

Patients with BPPV experience a decrease in health-related quality of life, which is restored after successful remission of BPPV following treatment with a particle repositioning maneuver.[35] However, health-related quality-of-life measures are not routinely used in treatment outcome studies.

A published overview of the Cochrane Collaboration (search dates: 1966–2004)[36] and 2 meta-analyses[37,38] evaluated the effectiveness of the CRP in the treatment of BPPV but did not evaluate other maneuvers. Two recently published practice guidelines[7,8] evaluated the effectiveness of the CRP, the liberatory maneuver, and the self-administered variants. These publications included assessments of the methodological quality of the studies evaluated. A rigorous qualitative synthesis needs to include an evaluation not only of the methodological quality but also of the precise performance of the intervention and the validity, reliability, and responsiveness of the tests used in the studies.[39]

The purpose of this systematic review was to determine whether patients diagnosed with PC BPPV on positional testing and treated with a particle repositioning maneuver will show the resolution of benign paroxysmal positional nystagmus (BPPN) on the DHT performed 24 hours or more after treatment. A synthesis of methodological quality was performed. The standards of methodological quality for this systematic review were randomization,[40] allocation concealment,[41,42] masking,[43] and sample size calculation.[44] The CRP, the liberatory maneuver, and the self-administered variants were evaluated. The inclusion and exclusion criteria were based on the findings of the proposed mathematical models of the treatment of BPPV[19–21] with the particle repositioning maneuvers to take into account the quality of the performance of the intervention and were based on the performance of the DHT as an outcome measure to take into account the validity and reliability of the outcome. The responsiveness of the DHT has not been reported in the literature.

Method

Data Sources and Searches

An electronic literature search of the MEDLINE, EMBASE, and CINAHL databases for the period from 1966 through September 2009 was conducted with the medical subject heading term "vertigo." In MEDLINE, to refine the search, the medical subject heading was combined with an "or" statement including "benign paroxysmal positional vertigo, BPPV, BPV, benign paroxysmal positional nystagmus, BPPN, or BPN." The search was restricted to English (possibly introducing publication bias). In CINAHL, the search was replicated with the same terms. In EMBASE, because of more specific indexing, the search was performed with the medical subject heading "vertigo" and the subheadings "BPPV" and "therapy." A published overview of the Cochrane Collaboration (search dates: 1966–2004),[36] 2 meta-analyses[37,38] of the treatment of PC BPPV, and 2 practice guidelines[7,8] were also reviewed. Bibliographies of the identified articles were manually searched for any additional relevant articles. The results of the searches were compared, and duplicates were removed (Fig. 3).

Study Selection

Published studies that reported on the effectiveness of particle repositioning maneuvers in the treatment of PC BPPV were eligible for inclusion. The inclusion criteria (Tab. 1) were as follows:

1. The study design was a randomized controlled trial (RCT) or quasi-RCT.

2. Participants had a clinical diagnosis of unilateral typical BPPV (PC involvement) on the basis of the findings on the DHT.[7,8]

3. A manual particle repositioning maneuver was performed. If the CRP was used, it included all 4 positions described originally by Epley[18] to optimize the removal of loose otoconia from the PC.[19–21] For the best outcome, simulated models of the CRP suggested from the initial head-hanging position a full 180-degree turn of the head toward the uninvolved side and a return to the upright position from the uninvolved side.[19–21] Acceptable modifications to the original CRP included self-administration,[26,27,45] performance of the procedure

Table 1.

Inclusion and Exclusion Criteria[a]

Parameter	Angeli et al[54]	Asawavichianginda et al[55]	Blakley[56]	Califano et al[57]	Cavaliere et al[58]	Chang et al[59]	Cohen and Kimball[60]	Froehling et al[49]	Li[61]	Lynn et al[33]
Inclusion criteria										
RCT, quasi-RCT		√	√	√	√	√	√	√	√	√
Typical BPPV	√	√	√	√	√	√	√	√		√
Intervention										
Manual particle repositioning maneuver	√	√	√	√	√	√	√	√	√	√
CRP with positions described by Epley[18]			√	√		√	√	√	√	√
Administered by:										
Clinician			√	√		√	√	√	√	√
Self										
Activity restrictions after treatment										
Yes	√	√						√	√	√
No			√	√	√	√	√			
Outcome										
DHT or side-lying test to assess nystagmus	√	√		√	√			√	√	√
Outcome assessed ≥24 h and <1 mo after treatment		√	√				√	√	√	√
Proportion of participants who converted from positive to negative DHT results reported	√	√							√	√
Exclusion criteria										
Cohort, retrospective, case-control, or case study	√									
No inclusion criteria									√	
Atypical BPPV										
Bilateral PC BPPV			√							
Central nervous system dysfunction										
Intervention: CRP with modification of positions described by Epley[18]	√	√								
Outcome: no DHT or side-lying test to assess nystagmus			√			√	√			

[a] RCT=randomized controlled trial, BPPV=benign paroxysmal positional vertigo, CRP=canalith repositioning procedure, DHT=Dix-Hallpike Test, PC=posterior canal.

Table 1.
Continued

Parameter	Massoud and Ireland[28]	Munoz et al[62]	Radtke et al[26]	Radtke et al[27]	Salvinelli et al[50]	Salvinelli et al[51]	Serafini et al[63]	Sherman and Massoud[52]	Soto Varela et al[53]	Sridhar et al[64]
Inclusion criteria										
RCT, quasi-RCT	√	√	√	√	√	√		√	√	√
Typical BPPV	√	√	√	√	√	√	√	√	√	√
Intervention										
Manual particle repositioning maneuver	√	√	√	√	√	√	√	√	√	√
CRP with positions described by Epley[18]	√	√	√	√				√	√	
Administered by:										
Clinician	√	√			√	√	√	√	√	√
Self			√	√						
Activity restrictions after treatment										
Yes	√									√
No	√	√	√	√	√	√		√	√	
Outcome										
DHT or side-lying test to assess nystagmus	√	√	√	√	√	√	√	√	√	√
Outcome assessed ≥24 h and <1 mo after treatment	√		√	√	√	√	√	√	√	√
Proportion of participants who converted from positive to negative DHT results reported	√	√	√	√	√	√	√	√	√	√
Exclusion criteria										
Cohort, retrospective, case-control, or case study			√				√			
No inclusion criteria										
Atypical BPPV										
Bilateral PC BPPV										√
Central nervous system dysfunction										
Intervention: CRP with modification of positions described by Epley[18]										
Outcome: no DHT or side-lying test to assess nystagmus										

(Continued)

Table 1.
Continued

Parameter	Tanimoto et al[45]	von Brevern et al[32]	Wolf et al[65]	Yimtae et al[66]
Inclusion criteria				
RCT, quasi-RCT	√	√	√	√
Typical BPPV	√	√	√	√
Intervention				
Manual particle repositioning maneuver	√	√	√	√
CRP with positions described by Epley[18]	√	√	√	
Administered by:				
Clinician	√	√	√	√
Self	√			
Activity restrictions after treatment				
Yes			√	
No	√	√		√
Outcome				
DHT or side-lying test to assess nystagmus	√	√	√	√
Outcome assessed ≥24 h and <1 mo after treatment	√	√	√	√
Proportion of participants who converted from positive to negative DHT results reported	√	√	√	√
Exclusion criteria				
Cohort, retrospective, case-control, or case study				
No inclusion criteria				
Atypical BPPV				
Bilateral PC BPPV			√	
Central nervous system dysfunction				
Intervention: CRP with modification of positions described by Epley[18]				√
Outcome: no DHT or side-lying test to assess nystagmus				

without the use of vibration,[22–24] no activity restrictions after the procedure,[28–30] and no premedication to avoid nausea.

4. The successful outcome of a particle repositioning maneuver was defined as the conversion of a positive DHT result to a negative DHT result or side-lying test result[33] 24 hours or more after the initial treatment procedure to avoid the fatiguing response[32] but less than 1 month later to separate the effects of active treatment from natural history.[34]

5. The proportion of participants who showed conversion from nystagmus to no nystagmus on the DHT at the time of follow-up was reported.

The exclusion criteria (Tab. 1) were as follows:

1. The study was a cohort study, a retrospective study, a case-control study, or a case study.

2. No inclusion criteria were described.

3. Participants had a clinical diagnosis of atypical BPPV (lateral canal or anterior canal involvement), bilateral PC BPPV due to confounding variables,[46] or central vestibular deficit.

4. The head positions of the CRP originally described by Epley[18] were modified. The CRP was performed with less than 180 degrees of head rotation from the initial head-hanging position and a return to the upright position from the involved side.[19–21]

5. The successful outcome of a particle repositioning maneuver was defined only as the resolution of vertigo.

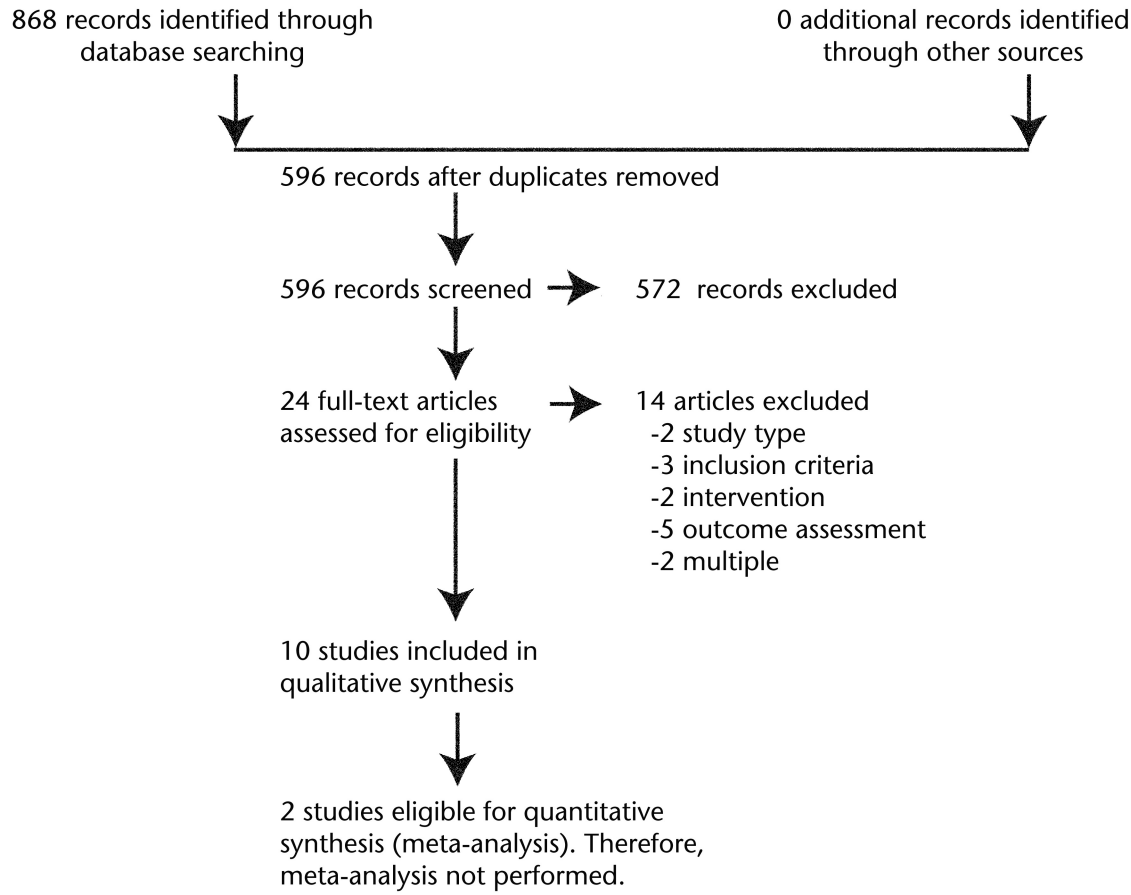

Figure 3.
Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement flow diagram of the literature search.

6. A successful outcome was assessed less than 24 hours after treatment.

7. The proportion of participants who showed successful conversion from nystagmus to no nystagmus on the DHT at the time of follow-up was not documented.

Data Extraction and Quality Assessment

Abstracts were screened. If the study was an RCT or a quasi-RCT and the study population was diagnosed with PC BPPV, then the article was obtained and reviewed by 2 reviewers (J.O.H. and D.S.Z.). When discrepancies occurred, the reasons were identified, and a final decision was made on the basis of the unanimous agreement of the authors (J.O.H., D.S.Z., and T.C.H.). The studies were stratified according to the particle repositioning maneuver.

The methodological quality standards for this systematic review were randomization,[40] allocation concealment,[41,42] masking,[43] and sample size calculation.[44] Lack of randomization, allocation concealment, or masking could change the treatment effects, resulting in study selection and confounding biases. Lack of calculation of the sample size could result in a greater risk of a type II error.[44]

Data were extracted, and a data form was completed to evaluate the methodological quality and quality of the interventions, tests, and outcomes of each study. The data collection form consisted of items compiled from a combination of instruments.[39,47,48] Information was obtained on the setting, study design, patient selection process, masking, intervention, outcomes, and statistics to evaluate the components of internal validity (selection bias, performance bias, detection bias, and attrition bias) and external validity (patients, intervention, setting, and outcomes) for potential bias. In addition, we compiled the following variables: patient report and quantitative outcomes on positional testing at short-term follow-up (first follow-up session) and long-term follow-up (if multiple follow-up sessions, last session), complications, and postprocedure instructions. When studies used re-

peated follow-up periods, the shortest time between 1 and 30 days to follow-up was used to allow for the strongest association between treatment and outcome. Studies that met the inclusion criteria were stratified according to the study design and intervention.

Data Synthesis and Analysis

To assess the outcome of each study, the effect size was calculated. The successful outcome of a particle repositioning maneuver was defined as the conversion of a positive positional test to a negative positional test (no BPPN). The patient's report of vertigo was not qualitatively analyzed. Two-by-two contingency tables were used to organize the outcome data. The odds ratio (OR) and the 95% CI were calculated to determine the odds of a successful outcome or a negative positional test. The OR measures the association between treatment and outcome. For quasi-RCTs comparing active treatments, the OR was calculated with the standard treatment (control) as the CRP. The CRP was selected as the standard of treatment because the 2 RCTs supported its effectiveness.[32,33] Only trials in which randomized treatment assignments and a clearly defined control group were used were considered for inclusion in a meta-analysis. Because only 2 such trials existed, a meta-analysis was not performed. We included quasi-RCTs and nonmasked trials in the systematic review. We acknowledge that these studies may be biased and may overestimate treatment efficacy.

Statistical analysis of the data was performed with SAS/STAT (version 9.1).* All tests of significance were performed at an α level of .05.

* SAS Institute Inc, 100 SAS Campus Dr, Cary, NC 27513-2414.

Results

Initially, 868 records were identified through an electronic database search (Fig. 3). From these records, 24 full-text articles were assessed for eligibility on the basis of their titles and abstracts. After complete articles were read, only 10 articles met the inclusion criteria,[27,28,32,33,45,49–53] and 14 met the exclusion criteria.[26,54–66] The main reasons for exclusion were study design, inclusion criteria (no inclusion criteria discussed or bilateral PC BPPV included), modifications to the head position used in the CRP, outcome not measured with a positional test, outcome assessed less than 24 hours or more than 1 month after treatment, and inadequate statistics (Tab. 1).

Of the 10 articles included in the qualitative synthesis, 2 studies used sealed envelopes with a computer-generated randomization code[32] or a block randomization scheme (numbered, sealed envelopes containing treatment group assignments, prepared before the start of the study)[33] to randomly allocate their participants to groups. Two studies quasi-randomly allocated their participants to groups on the basis of the date of their first visit.[51,52] Six studies stated that participants were randomly allocated to groups but did not describe the method of randomization.[27,28,45,49,50,53] Masking of participants and outcome occurred in 3 studies.[32,33,49] None of the studies reported calculation of the sample size.[27,28,32,33,45,49–53] Attrition was described but was not included in statistical calculations in 8 studies (intention-to-treat analysis)[27,28,32,33,45,49,52,53] and was not addressed in the remaining 2 articles.[50,51] A summary of the items included to assess the methodological quality of the studies is provided in Table 2.

Two RCTs[32,33] and 2 quasi-RCTs[49,52] compared the effectiveness of the CRP without vibration and the effectiveness of a sham treatment.[32,33,49,52] At short-term follow-up, the success rates for patients treated with the CRP were 67% to 95%,[32,33,49,52] those obtained with the sham treatment were 10% to 38%,[32,33,49,52] and that obtained with the control was 60%.[52] The magnitude of the effect of the CRP compared with that of the sham treatment was significant in all 4 studies.[32,33,49,52] Because of the small sample sizes and the wide confidence intervals, homogeneity could not be determined. The odds in favor of symptom resolution in the RCTs were 22 to 37 times higher in people receiving the CRP[32,33] and were more variable in the quasi-RCTs (3–25 times higher).[49,52]

Two quasi-RCTs compared the liberatory maneuver and no treatment (control).[50,51] At short-term follow-up, the success rates for patients treated with the liberatory maneuver were 80% to 85%, whereas spontaneous resolution in the control group was 35% to 38%. The odds in favor of symptom resolution were 7 to 10 times higher in patients receiving the liberatory maneuver than in the control group (Tab. 3). There may have been overlap of participants in these 2 studies because the data were collected over the same time periods by the same authors.[50,51]

Two quasi-RCTs compared the CRP and the liberatory maneuver.[28,53] At short-term follow-up, the success rates were 71% to 93% for the CRP and 74% to 92% for the liberatory maneuver. To calculate the OR, the CRP was selected as the standard of treatment. The odds in favor of symptom resolution were 0.80 and 1.16 higher in participants using the CRP, and the 95% CIs included 1, suggesting no significant difference in effectiveness between the liberatory maneuver and the CRP.

Table 2.
Summary of Methodological Quality[a]

Parameter	Froehling et al[49]	Lynn et al[33]	Massoud and Ireland[28]	Radtke et al[27]	Salvinelli et al[50]	Salvinelli et al[51]	Sherman and Massoud[52]	Soto Varela et al[53]	Tanimoto et al[45]	von Brevern et al[32]
Setting	Urgent care/IM	Oto	OP	Oto/Neuro	Oto	Oto	BD	Oto	Oto	Oto/Neuro
Study design	Quasi-RCT	RCT	Quasi-RCT	Quasi-RCT	Quasi-RCT	Quasi-RCT	Quasi-RCT	Quasi-RCT	Quasi-RCT	RCT
Participant selection										
Inclusion and exclusion criteria	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Method of randomization	No	Yes	No	No	No	No	No	No	No	Yes
Method of quasi-randomization	Yes		Yes	Yes	Yes	Yes	Yes	Yes	Yes	
Method of randomization concealed	No	Yes	No	No	No	No	No	No	No	Yes
Baseline comparability	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Masking										
Masking of participants	Yes	Yes	No	No	No	No	No	No	No	Yes
Masking of outcome	Yes	Yes	No	No	No	No	No	No	No	Yes
Intervention										
Treatment protocol adequately described	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Control or placebo adequate	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Testing of participant adherence to treatment protocol	No	Yes	No	Yes	No	No	No	No	Yes	No
Description of withdrawal and dropouts	NA	Yes	NA	Yes	No	No	Yes	Yes	Yes	Yes
Participant follow-up details reported	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes
Follow-up period adequate	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Outcomes										
Outcome measure described	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Relevant outcomes used	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

(Continued)

Table 2.
Continued

Parameter	Froehling et al[49]	Lynn et al[33]	Massoud and Ireland[28]	Radtke et al[27]	Salvinelli et al[50]	Salvinelli et al[51]	Sherman and Massoud[52]	Soto Varela et al[53]	Tanimoto et al[45]	von Brevern et al[32]
Use of quantitative outcome measure	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Statistics										
Descriptive measures identified and reported for primary outcome	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Appropriate statistics used	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
Sample size calculation performed	No	No	No	No	No	No	No	No	No	No
Adequate sample size	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Intention-to-treat analysis used	NA	No	NA	No	No	No	No	No	No	No

[a] IM=internal medicine, Oto=otolaryngology, OP=outpatient, Neuro=neurology, BD=balance and dizziness, RCT=randomized controlled trial, NA=not available.

Three quasi-RCTs reported the results of self-administered maneuvers[27,45,53] (Tab. 3). All of these studies compared 2 or more maneuvers. At 1 week, the success rates were 90% to 95% for the self-administered CRP or the CRP administered together with the self-administered CRP,[27,45] 58% for the self-administered liberatory maneuver,[27] and 24% for the Brandt-Daroff exercises.[53] The low success rate for the Brandt-Daroff exercises in those studies was contrary to the high success rate (98%) originally described in a 2-week, nonrandomized trial with longer treatment durations.[10] To calculate the OR, the CRP was selected as the standard of treatment. If CRP was not performed, then the self-administered CRP was selected. The odds in favor of symptom resolution were only 0.13 times higher in participants using the Brandt-Daroff exercises (OR=0.13, 95% CI=0.04–0.38) and 0.08 times higher in participants using the self-administered liberatory maneuver (OR=0.08, 95% CI=0.02–0.38) (Tab. 3). The odds in favor of symptom resolution were 3.54 times higher (95% CI=1.02–12.30) with the CRP plus the self-administered CRP than with the CRP alone (Tab. 3), suggesting better outcomes with the performance of a combination of the CRP plus the self-administered CRP.

Two RCTs[32,33] comparing the effectiveness of the CRP without vibration and the effectiveness of a sham treatment were eligible for quantitative synthesis. Because of the limited number of studies, a meta-analysis was not performed.

Discussion

This systematic review evaluated the effectiveness of several particle repositioning maneuvers, namely, the CRP, the liberatory maneuver, and the self-administered variants, in the treatment of PC BPPV. The present systematic review is a qualitative synthesis of methodological quality. Our inclusion and exclusion criteria took into account the quality of the performance of the intervention and the appropriateness of the tests and measures used.

Our inclusion and exclusion criteria were based on the findings of the proposed mathematical models for the treatment of BPPV[19–21] with the particle repositioning maneuvers. We excluded studies that included participants with bilateral BPPV to avoid confounding variables.[56,64,65] We did not rate the methodological quality of the articles but provided a description of the quality because not all of the qualitative scales addressed the quality of the physical therapy interventions and the validity, reliability, and responsiveness of the outcomes used.[39]

Our results agree with those of earlier reviews[7,8,36–38]—that the CRP is more effective than a control in the

Table 3.
Information Used to Code for Effect Size

Study	Group	Outcome				Outcome Measures	
		No. of Participants/ Group	No. of Participants With Negative Dix-Hallpike Test Result	% of Participants Cured	Reported Level of Significance (*P*)	Groups	Odds Ratio (95% Confidence Interval)
Lynn et al[33]	CRP	18	16	89	<.001	CRP vs sham	22.0 (3.41–141.73)
	Sham	15	4	27			
Massoud and Ireland[28,a]	CRP	46	43	93	>.2[b]	LM vs CRP	0.80 (0.17–3.79)
	LM	50	46	92			
Froehling et al[49]	CRP	24	16	67	.046	CRP vs sham	3.20 (1.00–10.20)
	Sham	26	10	38			
Sherman and Massoud[52]	CRP	33	27	82	.06	CRP vs sham	24.75 (4.31–142.02)
	Sham	13	2	15			
	Control	25	15	60			
Soto Varela et al[53,a]	Brandt-Daroff exercises	29	7	24	<.00001	Brandt-Daroff exercises vs CRP	0.13 (0.04–0.38)
	LM	35	26	74	.15315[b]	LM vs CRP	1.16 (0.42–3.18)
	CRP	42	30	71			
Salvinelli et al[50]	LM	40	32	80	<.01	LM vs control	6.67 (2.44–18.21)
	Control	40	15	38			
Radtke et al[27,c]	Self-administered CRP	37	35	95	<.001	Self-administered LM vs self-administered CRP	0.08 (0.02–0.38)
	Self-administered LM	33	19	58			
Salvinelli et al[51]	LM	52	44	85	<.001	LM vs control	10.39 (4.04–26.74)
	Flunarizine	52	30	58			
	Control	52	18	35			
Tanimoto et al[45,a]	CRP only	39	28	72	.048	Self-administered CRP vs CRP	3.54 (1.02–12.30)
	CRP and self-administered CRP	40	36	90			
von Brevern et al[32]	CRP	35	28	80	<.001	CRP vs sham	37.33 (8.75–159.22)
	Sham	31	3	10			

[a] Quasi-randomized controlled trial; standard treatment: canalith repositioning procedure (CRP).
[b] No significance of comparison of liberatory maneuver (LM) and CRP.
[c] Quasi-randomized controlled trial; standard treatment: self-administered CRP.

treatment of PC BPPV. On the basis of our inclusion and exclusion criteria, only 2 studies[32,33] met the criteria for quantitative synthesis; therefore, a meta-analysis was not performed. The greater variability in the quasi-RCTs may have been due to the clinical expertise of the study personnel[49] or to a difference in the patient populations. Professionals were trained to evaluate ocular nystagmus during positional testing.[49] The interrater reliability for interpreting the direction of eye movement varied depending on the level of expertise.[15] The low OR may reflect the lack of experience of the trained professionals in evaluating eye movements and may support the need for experienced professionals to treat BPPV to minimize delays in

treatment and reduce health care costs.

The liberatory maneuver was effective in the treatment of PC BPPV, and the quasi-RCTs found that the liberatory maneuver was as effective as the CRP. However, RCTs need to be performed to determine whether the liberatory maneuver is more effective for PC BPPV than a sham treatment and whether there is a correlation between the speed at which the maneuver is performed and the success of the maneuver.[19]

The self-administered CRP was more effective than the self-administered liberatory maneuver in the treatment of PC BPPV. More patients performed the self-administered liberatory maneuver incorrectly than performed the self-administered CRP incorrectly. The Brandt-Daroff exercises had little or no effect on symptom resolution.[53] Although this conclusion is based on a single randomized study, the low success rate of the Brandt-Daroff exercises was consistent with the findings of an earlier nonrandomized trial.[26] Therefore, the self-administered CRP has the highest reported treatment efficacy, whereas the Brandt-Daroff exercises have the lowest reported efficacy. For this reason, the Brandt-Daroff exercises are not recommended as an initial treatment maneuver. Patients should be physically and mentally screened to determine whether they are good candidates for instruction in and correct performance of self-administered maneuvers. To optimize outcomes, all patients should receive illustrated instructions with specific exercises for the affected ear, perform the exercises under the supervision of an experienced clinician, and be asked to perform the maneuver at the time of follow-up to assess the accuracy of performance.[27]

Although these data demonstrate that the CRP, the liberatory maneuver, and the self-administered variant of the CRP are effective treatments for PC BPPV,[27,28,32,33,45,49–53,57] clinicians must recognize that with both of these maneuvers, there is a chance (2.5%–6%) of causing a transient worsening of the patient's condition through a "canal conversion" from the PC to the lateral canal.[45,67] Because of this possibility, clinicians using these maneuvers should be able to recognize and treat lateral canal BPPV, although in most cases the complication resolves on its own. Patients performing self-administered treatments should be educated about the possibility of a canal conversion. Unfortunately, RCTs regarding the treatment of lateral canal BPPV are not available.

Limitations of Study/ Further Investigation

Only 2 RCTs[32,33] compared the effectiveness of the CRP and the effectiveness of a control in the treatment of PC BPPV. The limited number of studies prevented us from including the articles in a quantitative synthesis or meta-analysis. The methodological quality was low and the probability of bias was high in studies investigating the effectiveness of the liberatory maneuver and self-administered variants. Therefore, interpretation of the data should be limited. Randomized controlled trials investigating the effectiveness of the liberatory maneuver and self-administered variants need to be conducted.

The CRP was designed to use the forces associated with gravity to treat canalithiasis of the PC,[18] and the liberatory maneuver was designed to use both inertia and gravity to treat cupulolithiasis of the PC.[25] The mechanism of BPPV may be determined on the basis of the characteristic nystagmus parameters of latency to onset, duration, and amplitude. The nystagmus parameters were not reported for the particle repositioning maneuvers; therefore, correlations between the mechanism of BPPV and the outcome of the maneuvers could not be determined. Further research on this topic is needed.

Two studies reported by the same authors attempted to evaluate quality-of-life measures before and after the treatment of PC BPPV with the liberatory maneuver.[50,51] Information was insufficient to draw any conclusions. Further studies assessing the quality of life before and after the successful treatment of PC BPPV with particle repositioning maneuvers are needed.

We did not qualitatively assess the outcome of the patient's report of vertigo. The patient's report of vertigo may be assessed during the DHT or with the patient's daily routine (1 week before the follow-up appointment). The scales vary in that they use the frequency of reports of vertigo, the intensity of vertigo on an analog scale of 1 to 10, and categorization of the resolution of BPPV on the basis of a combination of subjective symptoms and findings on the DHT. There was considerable variability in the collection of the reports of vertigo. The resolution of vertigo was reported at follow-up during positional testing,[32,49] within 1 week of follow-up during daily activities,[33] at follow-up with the completion of a questionnaire (Vestibular Disorders Activities of Daily Living Scale[68]),[50,51] through categorization of the resolution of both symptoms and nystagmus[45,53] as first described by Epley,[18] or no mention of symptoms.[27,28,52] The development of a means for assessing the patient's report of vertigo is indicated.

Conclusion

Randomized controlled trials suggested that the CRP was more effec-

tive than a control in the resolution of BPPN in patients with PC BPPV. The evidence for the use of other particle repositioning maneuvers in the treatment of PC BPPV was weak. There were limited numbers of studies and no RCTs. Individual results suggested that the liberatory maneuver was more effective than a control; there was no significant difference in the effectiveness of the liberatory maneuver and the effectiveness of the CRP; the self-administered CRP was more effective than the self-administered liberatory maneuver; and the CRP administered together with the self-administered CRP was more effective than the CRP administered alone. The Brandt-Daroff exercises were the least effective self-administered treatments. There were no data on the effects of the particle repositioning maneuvers on outcomes relevant to patients.

Dr Helminski, Dr Zee, and Dr Hain provided concept/idea/research design and writing. Dr Helminski provided data collection and project management. Dr Helminski and Dr Janssen provided data analysis. Dr Hain provided consultation (including review of manuscript before submission). The authors acknowledge the assistance of Midwestern University's librarian, Rebecca Caton, MLIS, who assisted with the electronic literature search, and Sandra Levi, PT, PhD, for her guidance in writing this systematic review.

A poster presentation of data from this study was given at the Combined Sections Meeting of the American Physical Therapy Association; February 9–12, 2009; Las Vegas, Nevada.

This article was submitted March 10, 2009, and was accepted December 21, 2009.

DOI: 10.2522/ptj.20090071

References

1 von Brevern M, Radtke A, Lezius F, et al. Epidemiology of benign paroxysmal positional vertigo: a population based study. *J Neurol Neurosurg Psychiatry.* 2007;78:710–715.

2 Oghalai JS, Manolidis S, Barth JL, et al. Unrecognized benign paroxysmal positional vertigo in elderly patients. *Otolaryngol Head Neck Surg.* 2000;122:630–634.

3 Fife D, FitzGerald JE. Do patients with benign paroxysmal positional vertigo receive prompt treatment? Analysis of waiting times and human and financial costs associated with current practice. *Int J Audiol.* 2005;44:50–57.

4 Schuknecht HF. Cupulolithiasis. *Arch Otolaryngol.* 1969;90:765–778.

5 Hall SF, Ruby RR, McClure JA. The mechanics of benign paroxysmal vertigo. *J Otolaryngol.* 1979;8:151–158.

6 Dix MR, Hallpike CS. The pathology, symptomatology, and diagnosis of certain common disorders of the vestibular system. *Proc R Soc Med.* 1952;45:341–354.

7 Bhattacharyya N, Baugh RF, Orvidas L, et al. Clinical practice guideline: benign paroxysmal positional vertigo. *Otolaryngol Head Neck Surg.* 2008;139(5 suppl 4):S47–S81.

8 Fife TD, Iverson DJ, Lempert T, et al. Practice parameter: therapies for benign paroxysmal positional vertigo (an evidence-based review): report of the Quality Standards Subcommittee of the American Academy of Neurology. *Neurology.* 2008;70:2067–2074.

9 Aw ST, Todd MJ, Aw GE, et al. Benign positional nystagmus: a study of its three-dimensional spatio-temporal characteristics. *Neurology.* 2005;64:1897–1905.

10 Brandt T, Daroff RB. Physical therapy for benign paroxysmal positional vertigo. *Arch Otolaryngol.* 1980;106:484–485.

11 Epley JM. New dimensions of benign paroxysmal positional vertigo. *Otolaryngol Head Neck Surg.* 1980;88:599–605.

12 Herdman SJ. Treatment of benign paroxysmal positional vertigo. *Phys Ther.* 1990;70:381–388.

13 Baloh RW, Jacobson K, Honrubia V. Horizontal semicircular canal variant of benign positional vertigo. *Neurology.* 1993;43:2542–2549.

14 Halker RB, Barrs DM, Wellik KE, et al. Establishing a diagnosis of benign paroxysmal positional vertigo through the Dix-Hallpike and side-lying maneuvers: a critically appraised topic. *Neurologist.* 2008;14:201–204.

15 Blau P, Shoup A. Reliability of a rating scale used to distinguish direction of eye movement using infrared/video ENG recordings during repositioning maneuvers. *Int J Audiol.* 2007;46:427–432.

16 Harada Y. Metabolic disorder, absorption area and formation area of the statoconia. *J Clin Electron Microsc.* 1982;18:1–18.

17 Lim DJ. Formation and fate of the otoconia: scanning and transmission electron microscopy. *Ann Otol Rhinol Laryngol.* 1973;82:23–35.

18 Epley JM. The canalith repositioning procedure: for treatment of benign paroxysmal positional vertigo. *Otolaryngol Head Neck Surg.* 1992;107:399–404.

19 Faldon ME, Bronstein AM. Head accelerations during particle repositioning manoeuvres. *Audiol Neurootol.* 2008;13:345–356.

20 Hain TC, Squires TM, Stone HA. Clinical implications of a mathematical model of benign paroxysmal positional vertigo. *Ann N Y Acad Sci.* 2005;1039:384–394.

21 Rajguru SM, Ifediba MA, Rabbitt RD. Three-dimensional biomechanical model of benign paroxysmal positional vertigo. *Ann Biomed Eng.* 2004;32:831–846.

22 Hain TC, Helminski JO, Reis IL, Uddin MK. Vibration does not improve results of the canalith repositioning procedure. *Arch Otolaryngol Head Neck Surg.* 2000;126:617–622.

23 Macias JD, Ellensohn A, Massingale S, Gerkin R. Vibration with the canalith repositioning maneuver: a prospective randomized study to determine efficacy. *Laryngoscope.* 2004;114:1011–1014.

24 Motamed M, Osinubi O, Cook JA. Effect of mastoid oscillation on the outcome of the canalith repositioning procedure. *Laryngoscope.* 2004;114:1296–1298.

25 Semont A, Freyss G, Vitte E. Benign paroxysmal positional vertigo and provocative maneuvers [in French]. *Ann Otolaryngol Chir Cervicofac.* 1989;106:473–476.

26 Radtke A, Neuhauser H, von Brevern M, Lempert T. A modified Epley's procedure for self-treatment of benign paroxysmal positional vertigo. *Neurology.* 1999;53:1358–1360.

27 Radtke A, von Brevern M, Tiel-Wilck K, et al. Self-treatment of benign paroxysmal positional vertigo: Semont maneuver vs Epley procedure. *Neurology.* 2004;63:150–152.

28 Massoud EA, Ireland DJ. Post-treatment instructions in the nonsurgical management of benign paroxysmal positional vertigo. *J Otolaryngol.* 1996;25:121–125.

29 Roberts RA, Gans RE, DeBoodt JL, Lister JJ. Treatment of benign paroxysmal positional vertigo: necessity of postmaneuver patient restrictions. *J Am Acad Audiol.* 2005;16:357–366.

30 Cakir BO, Ercan I, Cakir ZA, Turgut S. Efficacy of postural restriction in treating benign paroxysmal positional vertigo. *Arch Otolaryngol Head Neck Surg.* 2006;132:501–505.

31 Baarsma EA. Vestibular testing in Ménière's syndrome [in Dutch]. *Acta Otorhinolaryngol Belg.* 1979;33:254–263.

32 von Brevern M, Seelig T, Radtke A, et al. Short-term efficacy of Epley's manoeuvre: a double-blind randomised trial. *J Neurol Neurosurg Psychiatry.* 2006;77:980–982.

33 Lynn S, Pool A, Rose D, et al. Randomized trial of the canalith repositioning procedure. *Otolaryngol Head Neck Surg.* 1995;113:712–720.

34 Imai T, Ito M, Takeda N, et al. Natural course of the remission of vertigo in patients with benign paroxysmal positional vertigo. *Neurology.* 2005;64:920–921.

35 Lopez-Escamez JA, Gamiz MJ, Fernandez-Perez A, Gomez-Finana M. Long-term outcome and health-related quality of life in benign paroxysmal positional vertigo. *Eur Arch Otorhinolaryngol.* 2005;262:507–511.

36 Hilton M, Pinder D. The Epley (canalith repositioning) manoeuvre for benign paroxysmal positional vertigo. *Cochrane Database Syst Rev.* 2004;2:CD003162.

37 Teixeira LJ, Machado JN. Maneuvers for the treatment of benign positional paroxysmal vertigo: a systematic review. *Braz J Otorhinolaryngol.* 2006;72:130–139.

38 Woodworth BA, Gillespie MB, Lambert PR. The canalith repositioning procedure for benign positional vertigo: a meta-analysis. *Laryngoscope.* 2004;114:1143–1146.

39 Olivo SA, Macedo LG, Gadotti IC, et al. Scales to assess the quality of randomized controlled trials: a systematic review. *Phys Ther.* 2008;88:156–175.

40 Chalmers TC, Celano P, Sacks HS, Smith H Jr. Bias in treatment assignment in controlled clinical trials. *N Engl J Med.* 1983; 309:1358–1361.

41 Moher D, Cook DJ, Eastwood S, et al. Improving the quality of reports of meta-analyses of randomised controlled trials: the QUOROM statement. Quality of Reporting of Meta-analyses. *Lancet.* 1999; 354:1896–1900.

42 Moher D, Cook DJ, Jadad AR, et al. Assessing the quality of reports of randomised trials: implications for the conduct of meta-analyses. *Health Technol Assess.* 1999;3:i–iv, 1–98.

43 Schulz KF, Chalmers I, Hayes RJ, Altman DG. Empirical evidence of bias: dimensions of methodological quality associated with estimates of treatment effects in controlled trials. *JAMA.* 1995;273:408–412.

44 Moher D, Dulberg CS, Wells GA. Statistical power, sample size, and their reporting in randomized controlled trials. *JAMA.* 1994; 272:122–124.

45 Tanimoto H, Doi K, Katata K, Nibu KI. Self-treatment for benign paroxysmal positional vertigo of the posterior semicircular canal. *Neurology.* 2005;65:1299–1300.

46 Longridge NS, Barber HO. Bilateral paroxysmal positioning nystagmus. *J Otolaryngol.* 1978;7:395–400.

47 Portney LG, Watkins MP. *Foundations of Clinical Research: Applications to Practice.* 3rd ed. Upper Saddle River, NJ: Pearson Prentice Hall; 2009.

48 Sherrington C, Herbert RD, Maher CG, Moseley AM. PEDro: a database of randomized trials and systematic reviews in physiotherapy. *Man Ther.* 2000;5:223–226.

49 Froehling DA, Bowen JM, Mohr DN, et al. The canalith repositioning procedure for the treatment of benign paroxysmal positional vertigo: a randomized controlled trial. *Mayo Clin Proc.* 2000;75:695–700.

50 Salvinelli F, Casale M, Trivelli M, et al. Benign paroxysmal positional vertigo: a comparative prospective study on the efficacy of Semont's maneuver and no treatment strategy. *Clin Ter.* 2003;154:7–11.

51 Salvinelli F, Trivelli M, Casale M, et al. Treatment of benign positional vertigo in the elderly: a randomized trial. *Laryngoscope.* 2004;114:827–831.

52 Sherman D, Massoud EA. Treatment outcomes of benign paroxysmal positional vertigo. *J Otolaryngol.* 2001;30:295–299.

53 Soto Varela A, Bartual Magro J, Santos Pérez S, et al. Benign paroxysmal vertigo: a comparative prospective study of the efficacy of Brandt and Daroff exercises, Semont and Epley maneuver. *Rev Laryngol Otol Rhinol (Bord).* 2001;122:179–183.

54 Angeli SI, Hawley R, Gomez O. Systematic approach to benign paroxysmal positional vertigo in the elderly. *Otolaryngol Head Neck Surg.* 2003;128:719–725.

55 Asawavichianginda S, Isipradit P, Snidvongs K, Supiyaphun P. Canalith repositioning for benign paroxysmal positional vertigo: a randomized, controlled trial. *Ear Nose Throat J.* 2000;79:732–734, 736–737.

56 Blakley BW. A randomized, controlled assessment of the canalith repositioning maneuver. *Otolaryngol Head Neck Surg.* 1994;110:391–396.

57 Califano L, Capparuccia PG, Di Maria D, et al. Treatment of benign paroxysmal positional vertigo of posterior semicircular canal by "Quick Liberatory Rotation Manoeuvre." *Acta Otorhinolaryngol Ital.* 2003;23:161–167.

58 Cavaliere M, Mottola G, Iemma M. Benign paroxysmal positional vertigo: a study of two manoeuvres with and without betahistine. *Acta Otorhinolaryngol Ital.* 2005; 25:107–112.

59 Chang AK, Schoeman G, Hill M. A randomized clinical trial to assess the efficacy of the Epley maneuver in the treatment of acute benign positional vertigo. *Acad Emerg Med.* 2004;11:918–924.

60 Cohen HS, Kimball KT. Effectiveness of treatments for benign paroxysmal positional vertigo of the posterior canal. *Otol Neurotol.* 2005;26:1034–1040.

61 Li JC. Mastoid oscillation: a critical factor for success in canalith repositioning procedure. *Otolaryngol Head Neck Surg.* 1995;112:670–675.

62 Munoz JE, Miklea JT, Howard M, et al. Canalith repositioning maneuver for benign paroxysmal positional vertigo: randomized controlled trial in family practice. *Can Fam Physician.* 2007;53:1049–1053, 1048.

63 Serafini G, Palmieri AM, Simoncelli C. Benign paroxysmal positional vertigo of posterior semicircular canal: results in 160 cases treated with Semont's maneuver. *Ann Otol Rhinol Laryngol.* 1996;105: 770–775.

64 Sridhar S, Panda N, Raghunathan M. Efficacy of particle repositioning maneuver in BPPV: a prospective study. *Am J Otolaryngol.* 2003;24:355–360.

65 Wolf M, Hertanu T, Novikov I, Kronenberg J. Epley's manoeuvre for benign paroxysmal positional vertigo: a prospective study. *Clin Otolaryngol Allied Sci.* 1999; 24:43–46.

66 Yimtae K, Srirompotong S, Srirompotong S, Sae-Seaw P. A randomized trial of the canalith repositioning procedure. *Laryngoscope.* 2003;113:828–832.

67 Herdman SJ, Tusa RJ. Complications of the canalith repositioning procedure. *Arch Otolaryngol Head Neck Surg.* 1996;122: 281–286.

68 Cohen HS, Kimball KT. Development of the Vestibular Disorders Activities of Daily Living Scale. *Arch Otolaryngol Head Neck Surg.* 2000;126:881–887.

Effectiveness of Particle Repositioning Maneuvers in the Treatment of Benign Paroxysmal Positional Vertigo: A Systematic Review

Janet Odry Helminski, David Samuel Zee, Imke Janssen and Timothy Carl Hain

PHYS THER. 2010; 90:663-678.
Originally published online March 25, 2010
doi: 10.2522/ptj.20090071