

Symptom Resolution Rates of Posttraumatic versus Nontraumatic Benign Paroxysmal Positional Vertigo: A Systematic Review

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Abstract

Objective. To determine the rate of symptom resolution in patients with posttraumatic benign paroxysmal positional vertigo (BPPV) and to determine if it differs from resolution rates in patients with BPPV and without a history of head trauma.

Data Sources. Systematic review of the literature was performed using Medline, EMBASE, and Cochrane databases. English and French articles meeting inclusion criteria and published between 1946 and October 2014 were included.

Review Methods. Data were independently extracted from the articles by 2 reviewers using data collection forms developed a priori. Inclusion and exclusion criteria were decided a priori. Studies were included if they reported on at least 1 case of posttraumatic BPPV (t-BPPV), reported on outcomes of all patients with t-BPPV, had a clearly defined inception point, and provided a clear diagnosis of BPPV (defined a priori by reviewers).

Results. A total of 3017 titles, 362 abstracts, and 67 articles were reviewed, from which 16 articles met inclusion criteria and underwent data extraction. There were a total of 207 patients with posttraumatic BPPV identified. Among the 207 patients, 151 (73%) had resolution of symptoms. The t-BPPV patients may have more multi-canal involvement and may require more repositioning maneuvers for resolution compared to patients with nontraumatic BPPV.

Conclusions. Available evidence does not support the notion that symptom resolution rates in patients with posttraumatic BPPV are worse than those with nontraumatic BPPV. However, well-designed studies with adequate cohorts are lacking. Additional well-executed studies are needed to confirm this lack of difference in resolution rates.

Keywords

BPPV, benign paroxysmal positional vertigo, wounds and injuries, craniocerebral trauma, posttraumatic BPPV

Introduction

Benign paroxysmal positional vertigo (BPPV) is one of the most common causes of vertigo. It is characterized by recurrent, short-lasting episodes of vertigo brought on by changes in head position in the plane of the affected canal. It occurs most frequently in the posterior semicircular canal (SCC); however, the lateral and superior SCCs can also be affected, in decreasing order of frequency.¹

In most patients with BPPV, there is no identifiable cause. However, BPPV can occur with viral neurolabyrinthitis, Ménière's disease, migraine, or following head trauma, with the latter representing 8.5%² to 18%³ of patients diagnosed with BPPV. There are no accepted criteria for making the diagnosis, specifically, of posttraumatic vertigo (t-BPPV). Some define traumatic BPPV by the onset of characteristic symptoms occurring within 3 days^{2,3} of the head trauma, whereas others extend the time period to 3 months.⁴

Diagnostic and therapeutic maneuvers for patients with BPPV are the same whether as a result of trauma or not. The diagnosis is usually evident on Dix-Hallpike or supine head roll testing. Therapeutic options include: conservative management; repositioning maneuvers, which are considered first-line therapy; and surgery, for recalcitrant cases.

Anecdotally, there is a perception that the rate of resolution of symptoms in patients with t-BPPV is lower than that of

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patients with BPPV and no history of trauma (nontraumatic and idiopathic causes; termed i-BPPV herein). This has important implications, if true, when neurologists are asked to predict patient prognosis in a medical legal setting.

The primary objective of this systematic review was to determine whether or not the rate of symptom resolution in patients with t-BPPV differs from that in patients with i-BPPV. Our secondary outcomes included determining whether or not multi-canal involvement differed between t-BPPV and i-BPPV patients as well as the number of repositioning maneuvers (RPM) required by patients with t-BPPV were different than with i-BPPV. These 2 factors each may contribute to the perception that symptoms in this patient population are more persistent.

Methods

Search Strategy

A systematic review of the literature was performed using established methodology for systematic reviews.⁵ A search of the Medline (Ovid) database from 1946 to October 26, 2014, was supplemented by searches of EMBASE (1974–October 2014) and Cochrane Central Register of Control Trials (up to October 2014). References of identified articles were manually searched for additional pertinent studies. Detailed search strategy is available in Appendix 1 (available at www.otojournal.org/supplemental). Ethics review board approval was not obtained for this study given that it was a systematic review of studies, the contents of which could not be traced back to the original patients. There was no funding or other third-party influence, and no human subjects were studied as part of this review.

Study Inclusion and Exclusion Criteria

Studies were included if they:

- included at least 1 case of t-BPPV in humans;
- reported outcomes of the entire group of patients with t-BPPV;
- clearly defined an inception point (time of trauma or time of diagnosis);
- provided a clear diagnosis of BPPV, defined as 1 of the following:
 - diagnosis determined by a neurologist or otolaryngologist
 - appropriate positioning diagnostic maneuvers specifically stated or properly described;
 - acceptable if specific nystagmus direction not specified but if specified must describe appropriate nystagmus for diagnosis;
- no age or gender distinctions were applied;
- English or French publications.

The following exclusion criteria were applied:

- editor's note/response to author publications;
- review articles;

- diagnosis stated by specialist other than otolaryngologist or neurologist or no mention of confirmation with positioning maneuvers;
- lack of reported outcome data;
- publication in language other than English or French.

Changes to Protocol during Study

During review of articles, an addendum was added to exclude articles with more than 3 months between the occurrence of the trauma and diagnosis of BPPV.⁴ The protocol was further clarified such that patients with vertigo following *acoustic* trauma (blast injuries) were also excluded.

Selection of Articles

The research protocol and data extraction forms (available on request) were developed a priori. All steps of the review were performed independently by 2 researchers experienced or specifically trained in literature search strategies. A third researcher resolved discrepancies. Two reviewers independently extracted data from all included articles with consensus achieved in all parameters. When there was missing or unclear information from articles that had met inclusion criteria, attempts were made to contact authors by email: emails were sent out to 4 authors, none of whom responded with sufficient information to be included.

Assessment of Risk of Bias

Risk of bias was assessed using Tools for Bias developed by The Clarity Group and Evidence Partners 2011.⁶

Statistics

No statistical testing was used in this review. The noted *P* values herein are those taken directly from the reviewed article

Comparison Group for t-BPPV Group

This systematic review was designed to identify all patients with t-BPPV in whom symptom resolution was reported in the literature. A decision was made a priori to use a general population of patients with BPPV (all-comers) in whom outcomes are reported from a reputable and reliable source with which to compare outcomes of the t-BPPV group extracted from this systematic review (should these data not be available in the identified studies). Data from a recently updated Cochrane review⁷ comparing outcomes between Epley maneuver and other treatment options in all-comers with BPPV was selected as a comparison for t-BPPV group outcomes.

Results

Systematic Review of the Literature

The search strategy identified 3017 articles of potential relevance. After exclusion of duplicates and irrelevant titles, 362 articles were chosen for abstract review. Exclusion of 295 abstracts that were deemed irrelevant or were published in a language other than English or French restricted the set to 67 studies that were reviewed in detail. Fifteen articles and 1 additional pertinent reference (identified during manual

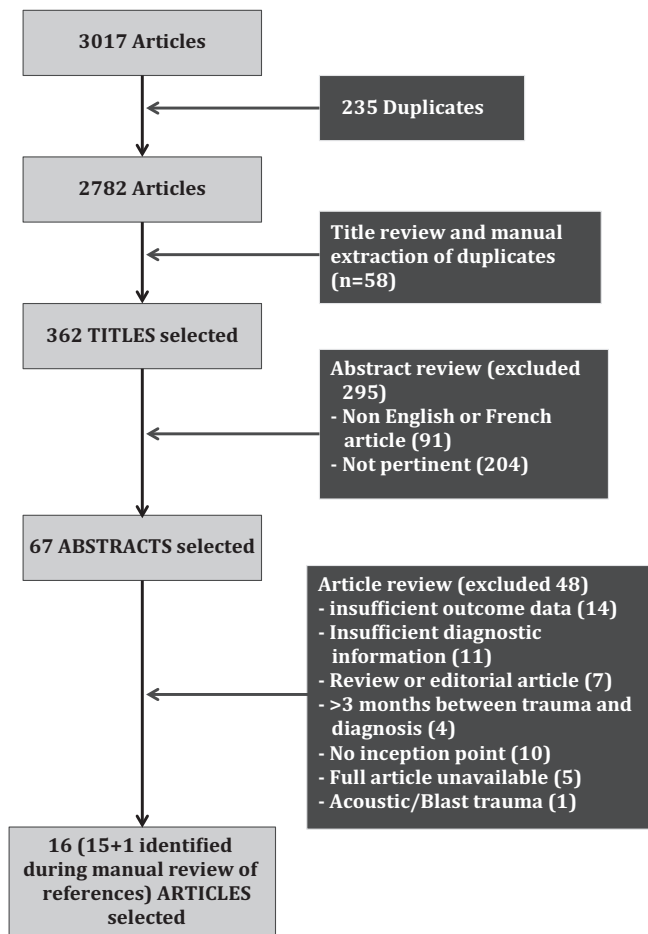


Figure 1. Flow diagram for selection of studies included in the systematic review.

review of references) met inclusion criteria and were included in this review, making a total of 16 included articles^{2,4,8-21} (**Figure 1**).

Among the 16 included articles, data were available on 207 patients, ranging from 1 to 51 patients in each study (**Table 1**). Demographic information was available for all but 3 studies.^{4,11,18} Twelve of the articles clearly described treating all affected patients with RPMs,^{2,4,8,10-12,14-17,19,21} whereas 2 studies used RPMs in some patients,^{9,13} and 2 articles did not report whether or not they used RPMs.^{18,20}

Study quality assessment analysis was performed separately for case series/case reports (**Table 2**) and cohort studies (**Table 3**) in compliance with the use of the study quality assessment tool: Tools for Bias developed by The Clarity Group and Evidence Partners 2011.⁶

Articles Comparing t-BPPV and i-BPPV Patients

Four articles^{2,4,8,19} included outcome data on cohorts of both t-BPPV and i-BPPV patients and particularly warrant specific discussion. All 4 of these articles reported on BPPV resolution rates, 3 reported on rate of multi-canal involvement, and 3 reported on numbers of RPMs required in both groups. The total number of i-BPPV and t-BPPV patients reported in these

4 studies was 525 and 144, respectively. All 4 studies were retrospective (cohort study) chart reviews.

A fifth article, by Dispenza et al,²¹ mentioned i-BPPV cohorts from 2 separate publications (from their center)^{22,23} in their article and compared the number of RPMs needed between their t-BPPV cohort in 1 study and the i-BPPV groups from the 2 other publications. The data from these publications were extracted and are included in the pertinent tables.

A variable potential for bias was present in the 4 cohort studies.^{2,4,8,19} Ahn et al⁸ reported on a “consecutive” group of t-BPPV patients from whom a subset was chosen based on clearly defined inclusion criteria. Although the control group was selected from the same time period, the authors did not specify whether or not these patients represented a consecutive group. Follow-up appeared to be equal between groups; however, it was not specifically stated if there were any losses to follow-up. Gordon et al² performed a retrospective chart review of patients with posterior SCC BPPV over a specified time period. They included all t-BPPV cases from that time period and selected their i-BPPV (control) group from a larger patient subset in order to have 2 i-BPPV patients for every 1 t-BPPV patient. The authors did not specifically describe how each of the i-BPPV patients was chosen. Furthermore, by including only posterior SCC BPPV cases, bias may be introduced with regards to outcome and prognosis. Otherwise, both groups seemed to have been treated and followed up equally, although the authors did not comment specifically on whether or not there were any losses to follow-up. Liu et al⁴ performed a retrospective analysis of i-BPPV and t-BPPV patients over a specified time period but did not describe how the charts were selected or if they represented all patients with said diagnoses in the given time period. Details about the t-BPPV group were clearly provided, but parallel data on the i-BPPV group were not included. Otherwise, both groups seemed to have been treated and followed up equally, although the authors did not comment specifically on if there were any losses to follow-up. Suarez et al¹⁹ reported a retrospective chart review of both i-BPPV and t-BPPV patients. The authors did not provide any specification about how patients were selected for review. Follow-up was not specified for either group, and there were no comments with regards to loss to follow-up.

Primary Outcome: Resolution Rate of t-BPPV

Resolution of symptoms of t-BPPV at last follow-up occurred in 151 of 207 patients (73%; range, 33%-100%) (**Table 4**). For articles in which the authors report recurrence of symptoms during the follow-up period, the patients with recurrence were classified as having persistent or unresolved BPPV. Reporting of trauma severity was not standardized among articles but, when reported, are noted in **Table 4**.

There was no clear correlation between the number of patients in a given study and resolution rate (**Figure 2**), although the results of the smaller studies appeared to cluster around 100% resolution rates. To assess for potential effect of bias, the pooled data of only articles with 10 patients or more were analyzed ($n = 7$). These 7 articles reported on a total of 194 patients, 138 of

Table 1. Study Characteristics.^a

Author, y	Study Type	No.	Age (y) ^b	Gender (M:F)	Time between Trauma and Diagnosis	RPM Used (Y/N/NA)
Ahn et al, 2011	Retrospective cohort study	32	52.9 ± 11.2 (30-74)	18:14	<72 h	Y
	t-BPPV group					
	i-BPPV group	112	55.3 ± 15.9 (11-83)	44:68		Y
			(P > .05)	(P < .05)		
Bertholon et al, 2005	Retrospective case series	3	39.7 (19-49)	2:1	8.3 d mean (4-14 d)	Variable
Bockisch et al, 2014	Case report	1	96	1:0	NA	Y
Cornacchia et al, 2006	Case report	1	NA	1:0	3 mo	Y
Gordon et al, 2004	Retrospective cohort study	21	56.3 ± 15.6 (24-84)	10:11	3 d	Y
	t-BPPV group					
	i-BPPV group	42	61.1 ± 22.3 (34-83)	10:32		Y
Hornibrook et al, 1998	Case report	1	51	1:0	5 d	Y
Kim et al, 2013	Case report	1	22	0:1	10 d	Variable
Liu et al, 2012	Retrospective cohort study	40	NA	NA	≤ 3 mo	Y
	t-BPPV group					
	i-BPPV group	46	NA	NA		Y
Motin et al, 2005	Prospective Case series	10	43 ± 12 (19-61)	8:2	67 ± 14 days	Y
Persichetti et al, 2004	Case report	1	38	0:1	0 d	Y
Ralli et al, 2010	Case series	2	50 (40;60)	1:1	10 d; 3w	Y
Rodriguez et al, 2007	Case series	2	46.5 (31-62)	1:1	0 d	Y
Saito et al, 1986	Case series	22	NA	NA	<7 d	NA
Suarez et al, 2010	Retrospective cohort study	51	47.9 ± 18.6 (19-78)	20:31	<15 d	Y
	t-BPPV group					
	i-BPPV group	325	58.9 ± 14 (23-84)	68:257		Y
			(P = .0005)	(P = .04)		
Vibert et al, 2003	Case report	1	57	1:0	2 mo	NA
Dispenza et al, 2011^c	Case series/cohort^c	18	38.2 (25-66)	11:7	7 d	Y
	t-BPPV group					
	i-BPPV group^{d,22}	58	NA (27-81)	23:35		Y
	i-BPPV group^{e,23}	412	55.4 (14-90)	173:239		Y

Abbreviations: i-BPPV, nontraumatic and idiopathic causes of benign paroxysmal positional vertigo; NA, not available; t-BPPV, posttraumatic benign paroxysmal positional vertigo.

^aArticles in bold report >10 cases t-BPPV.

^bMean ± SD (range) as reported when available; calculated for case series; individual ages for case reports.

^cThis publication is a retrospective case series presenting the t-BPPV group's data; however, it includes a table comparing number of repositioning maneuvers required for resolution in t-BPPV versus i-BPPV based on 2 previous publications that are referenced.^{22,23} Data in this table for i-BPPV group are taken from these 2 referenced articles.

^dGeotropic lateral canal BPPV only; all-comers with BPPV.

^eIdiopathic BPPV with nystagmus; excluded multi-canal involvement.

whom experienced symptom resolution at the time of last follow-up (71%; range 33%-100%). In all but 1 of these studies, the t-BPPV patients had undergone treatment with RPMs, suggesting that the studied group was, for the majority, a treated group of patients with BPPV. If the 1 study in which it was not clearly stated if patients were treated with RPM or not is excluded, we are left with a "treated group" of 172 t-BPPV patients, 116 of whom resolved (67%).

Four articles compared recurrence rates of BPPV between patients with t-BPPV and i-BPPV (**Table 5**). Two of these 4 studies suggested a statistically significantly higher recurrence rate in

t-BPPV patients as compared to i-BPPV patients, whereas the other 2 studies did not find any statistically significant difference.

Secondary Outcome: Rate of Multi-Canal Involvement

Fourteen articles^{2,4,8-15,17,19-21} (n = 183) specifically addressed which semicircular canal(s) were affected by t-BPPV (**Table 6**). Four cohort studies^{2,4,8,19} reported on similar data in their i-BPPV control group. Of the 183 t-BPPV patients, 63 (34%) had either bilateral (n = 15) or multi-canal (n = 48) involvement. Of the 183 i-BPPV patients, 34 (6%) had either bilateral (n = 27) or

Table 2. Study Quality Assessment for Included Case Series (Case Reports Included).

Author, y	Retro (R) or Prospective (P)	Representative Source Population?	Is Outcome Assessment Accurate?	Are There Little Missing Data?
Bertholon et al, 2005	P	Definitely no (selected for multi-canal—concurrent PC and HC—involvement)	Definitely yes	Definitely yes
Bockisch et al, 2014	R	Probably yes (elderly patient, post fall)	Definitely yes	Definitely yes
Cornacchia et al, 2006	R	Definitely no (trauma to head from firecracker)	Definitely yes	Definitely yes
Hornibrook et al, 1998	R	Probably yes (fall from a motorcycle)	Definitely yes	Definitely yes
Kim et al, 2013	R	Probably no (selected after orthognathic surgery)	Definitely yes	Definitely yes
Motin et al, 2005	P	Probably no (selected for severe TBI, admitted to rehabilitation center)	Definitely yes	Definitely yes
Persichetti et al, 2004	R	Probably no (selected after rhinoplasty surgery)	Probably yes (Semont's diagnostic maneuver)	Definitely yes
Ralli et al, 2010	R	Definitely no (selected for falls off camel)	Definitely yes	Definitely yes
Rodriguez et al, 2007	R	Probably no (selected after dental surgery procedures)	Definitely yes	Definitely yes
Saito et al, 1986	R	Probably yes (selected for head injuries sustained in traffic accidents, no further details)	Probably yes (“positioning nystagmus testing”)	Probably yes (not clearly stated)
Vibert et al, 2003	R	Probably yes (post car accident)	Probably yes (D-H not stated but OHNS authors)	Probably no (follow-up time not clearly defined)

Abbreviations: D-H, Dix-Hallpike; HC, horizontal canal; OHNS, otolaryngology—head and neck surgery; PC, posterior canal; TBI, traumatic brain injury.

multi-canal ($n = 7$) involvement. However, there was a significant amount of data lacking, and presence or absence of multi-canal involvement was not always specified, which should suggest caution be exercised when interpreting these data.

Three articles^{4,8,19} explicitly compared the rate of multi-canal involvement in both t-BPPV and i-BPPV groups (**Table 6**). Two of these studies^{4,19} (reporting on a total of 91 t-BPPV and 371 i-BPPV patients) found the t-BPPV patients to have statistically significantly higher rates of multi-canal involvement as compared to the i-BPPV group. The third study⁸ (comparing 32 t-BPPV and 112 i-BPPV patients) did not find a statistically significant difference between the groups.

Secondary Outcome: Number of Repositioning Maneuvers Required per Affected Canal

Twelve articles^{2,4,8-11,13-17,21} ($n = 132$) reported on the number of repositioning maneuvers performed (**Table 7**). Overall, 64 (48%) patients with t-BPPV responded to a single repositioning maneuver per affected canal. In cases of multicanal involvement, a subject may have undergone more than 1 RPM, but if it was 1 RPM per canal (ie, one Epley maneuver to cure posterior canal BPPV and one log-roll maneuver for horizontal canal BPPV), they were still considered to have resolved after a single RPM.

Three studies,^{2,4,8} reporting on a total of 90 t-BPPV and 193 i-BPPV patients, statistically analyzed the proportion of cases

requiring multiple RPMs in t-BPPV patients as compared to i-BPPV patients (**Table 7**). All 3 found that t-BPPV patients were statistically significantly more likely to require multiple RPMs for resolution. A fourth article, by Dispenza et al,²¹ published data on number of RPMs needed in a t-BPPV cohort and compared these data to data from previous publications from their center on RPMs for lateral canal (LC) BPPV²² and posterior canal (PC) and LC BPPV²³ but did not perform any statistical comparisons between the groups.

Summary of 2014 Cochrane Review Findings

In 2014, a Cochrane review⁷ appraised the literature on all patients with BPPV to assess the effectiveness of the Epley maneuver. The cause of BPPV was not specified and thus likely includes patients with traumatic as well as nontraumatic BPPV, the former of which may represent 8.5% to 18% of the patients based on reported incidence of t-BPPV in the literature.^{2,3} The comparison groups were either patients who underwent no treatment or a placebo treatment or patients who underwent other repositioning maneuvers. The 2 outcomes studied were symptom resolution and conversion of a positive to a negative Dix-Hallpike test. Extracting data from the published tables, the rate of Dix-Hallpike conversion in all patients having undergone Epley maneuvers is 80% (287/361), and the rate of Dix-Hallpike conversion in all patients (Epley, control/placebo, Brandt-Daroff, Semont, Gans) is 63%

Table 3. Study Quality Assessment for Included Cohort studies.

Author, y	Cohorts Drawn from Same Population?	Assessment of Exposure?	Outcome Not Present at Start?	Did Study Match Group for Relevant Variables?	Was Absence or Presence of Prognostic Factors Assessed?	Outcome Assessed?	Adequate Follow-Up?	Co-Interventions Similar?
Ahn et al, 2011	Probably yes (affected patients over specified time period meeting inclusion criteria)	Probably yes	Probably yes	Mostly no (i-BPPV more restricted group)	Probably yes	Definitely yes (clearly defined D-H; absence of nystagmus and vertigo)	Probably no	Definitely yes (clearly defined protocol to repeat RPM)
Gordon et al, 2004	Probably yes (t-BPPV group selected over specified time period; 2 i-BPPV for every 1 t-BPPV selected—no additional explanation)	Probably yes	Probably yes	Mostly no	Probably yes	Probably yes (positive for vertigo; no mention of nystagmus though; used D-H)	Probably yes	Definitely yes (clearly defined protocol to repeat RPM and outcome assessment)
Liu et al, 2012	Probably yes	Definitely yes (“well-documented head trauma”)	Probably yes	Mostly yes	Probably yes	Probably yes (D-H but not clear if both vertigo and nystagmus)	Probably yes	Definitely yes (clearly defined protocol to repeat RPM and outcome assessment)
Suarez et al, 2010	Probably yes (same clinic)	Probably yes (mild head trauma)	Probably yes	Mostly yes	Probably yes	Probably yes (otolaryngologist; use of D-H not clearly stated)	Probably no (not stated how long followed)	Probably no (frequency of RPM not described)
Dispenza et al, 2007*	Definitely no (took from different study, albeit same group and same center)	Probably yes (whiplash injury)	Probably yes	Mostly no (some different inclusion criteria)	Definitely no (excluded multi-canal involvement, for instance)	Probably yes (different papers)	Probably yes (followed to resolution but duration not clearly stated)	Probably no (2 different papers; different time frames)

Abbreviations: D-H, Dix-Hallpike; i-BPPV, nontraumatic and idiopathic causes of benign paroxysmal positional vertigo; RPM, repositioning maneuvers; t-BPPV, posttraumatic benign paroxysmal positional vertigo.

*See note for this article in footnote of Table 1.

(462/736; note that the calculated total number of patients reported on adds up to 736 in the tables and not the reported 745 described by the authors). The rate of symptom resolution, as extracted from the studies that used only symptom resolution as their outcome, was 56% (79/140) for the Epley group and 21% (28/133) for the control group. In order to assess the potential effect of inclusion of t-BPPV patients on the review's outcomes, all 11 included articles were searched. Nine of the 11 articles were retrievable in English and were reviewed in detail. The last 2 were published in Chinese and

not retrievable in English.^{24,25} Two of the 9^{26,27} reviewed articles (representing a total of 138 patients; 68 having undergone Epley maneuver and 70 having undergone Semont or Brandt-Daroff maneuvers) had applied history of trauma as an exclusion factor for their patient selection. Resolution of nystagmus upon Dix-Hallpike testing in this group of nontraumatic BPPV patients was seen in 54 of 68 (80%) of patients treated with the Epley maneuver and 91 of 138 (67%) patients overall. There were no control or placebo groups included in these 2 studies that may explain the slightly higher resolution rate

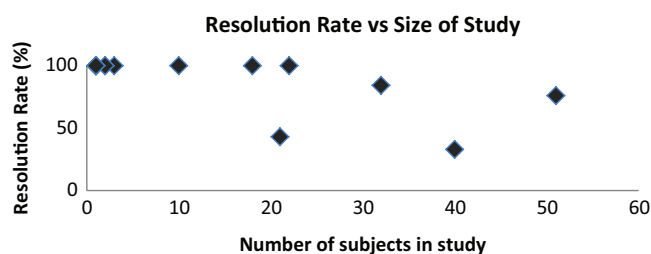
Table 4. Primary Objective: BPPV Resolution Rates.^a

Author, y	t-BPPV Resolution Rate (%)	Type of Trauma	Follow-Up Time	i-BPPV Resolution Rate (%)	Follow-Up Time	Use of Physical Examination (PE) or Symptom Relief (SR) in Follow-Up ^b
Ahn et al, 2011	27/32 (84%)	MVA (20), fall (8), blow to head (4)	32.4 mo ± 9.3	21/112 (19%)	35.2 mo ± 9.9	PE
Bertholon et al, 2005	3/3 (100%)	MVA (1), fall (2)	2 y (range, 11 mo-3.8 y)			PE
Bockisch et al, 2014	1/1 (100%)	Fall				PE
Cornacchia et al, 2006	1/1 (100%)	Blunt trauma	1 y (100%)			PE
Gordon et al, 2004	9/21 (43%)	MVA (12), fall (4), blow to head (1), osteoma/dental/VP shunt surgery (2), speedboat trip (1)	21.7 mo ± 9.7	34/42 (81%)	21.7 mo ± 9.7	PE
Hornibrook et al, 1998	1/1 (100%)	Fall	5 w			PE
Kim et al, 2013	1/1 (100%)	Orthognathic surgery	1 mo			PE
Liu et al, 2012	13/40 (33%)	NA	12 mo	42/46 (91%)	12 mo	PE
Motin et al, 2005	10/10 (100%)	Severe traumatic brain injury				PE
Persichetti et al, 2004	1/1 (100%)	Post rhinoplasty	3 mo			PE
Ralli et al, 2010	2/2 (100%)	Fall	5 d, 1 y			PE
Rodriguez et al, 2007	2/2 (100%)	Post dental implantation				SR
Saito et al, 1986	22/22 (100%)	MVA Araki II (12), Araki III (10)				PE
Suarez et al, 2010	39/51 (76%)	Mild head trauma		218/325 (67%)		PE
Vibert et al, 2003	1/1 (100%)	MVA	18 mo			SR
Dispenza et al, 2011	18/18 (100%)	Whiplash injury	6 mo			SR
Total:	151/207 (73%)			315/525 (60%)		

Abbreviations: i-BPPV, nontraumatic and idiopathic causes of benign paroxysmal positional vertigo; MVA, motor vehicle accident; NA, not available; RPM, repositioning maneuvers; t-BPPV, posttraumatic benign paroxysmal positional vertigo.

^aBold indicates articles with >10 cases.

^bIf authors mentioned positioning testing, physical examination or electronystagmography (ENG) during follow-up (even if not at the last follow-up), article was considered to use PE during follow-up. In some cases, nystagmus was not specifically mentioned in follow-up, but if absence of vertigo during physical examination was mentioned, PE was considered to have been used in follow-up.

**Figure 2.** Benign paroxysmal positional vertigo resolution rate as a function of study size.

(67% vs 63%) in this group as compared to all-comers with BPPV in all treatment (including placebo/control) groups. Nonetheless, the rates of nystagmus resolution are similar when comparing all-comers with BPPV (that may include up to 18% t-BPPV patients) to a group of BPPV patients with no history of trauma.

Although the specific diagnosis of PC BPPV was not a specified inclusion criterion, it may be inferred based on the use of diagnostic and therapeutic methods (Dix-Hallpike used as diagnostic maneuver; posterior SCC repositioning maneuvers, such

Table 5. Rate of BPPV Recurrence of t-BPPV versus i-BPPV.

Author, y	t-BPPV, % (No.)	i-BPPV	P Value
Ahn et al, 2011	16 (5/32)	19 (21/112)	.685
Gordon et al, 2004	57 (12/21)	19 (8/42)	.004
Liu et al, 2012	67 (27/40)	8 (4/46)	.001
Suarez et al, 2010	24 (12/51)	33 (107/325)	.18
Total	39 (56/144)	27 (140/525)	

Abbreviations: BPPV, benign paroxysmal positional vertigo; i-BPPV, nontraumatic and idiopathic causes of benign paroxysmal positional vertigo; t-BPPV, post-traumatic benign paroxysmal positional vertigo.

Table 6. Secondary Outcome: Rate of Multicanal Involvement.^a

Author, y	No.	PC	HC	AC	Bilateral BPPV	Multiple canals (NOS)
Ahn et al, 2011	32 (t-BPPV)	22	10	0	1	3
	112 (i-BPPV) ^b	69	43	0	3	4
Bertholon et al, 2005	3	3	3			3
Bockisch et al, 2014	1	1				
Cornacchia et al, 2006	1	1				
Gordon et al, 2004	21 (t-BPPV)	21	2			4
	42 (i-BPPV)	42				
Hornibrook et al, 1998	1	1				1
Kim et al, 2013	1	1			1	1
Liu et al, 2012	40 (t-BPPV)				10	22
	46 (i-BPPV) ^c				1	3
Motin et al, 2005	10	10				4
Persichetti et al, 2004	1	1				
Rodriguez et al, 2007	2	2				
Suarez et al, 2010	51 (t-BPPV)	48	3		9	
	325 (i-BPPV) ^d	310	11	4	23	
Vibert et al, 2003	1					1
Dispenza	18	16	2			
Total	183 (t-BPPV)	127 (69%)	20 (11%)		15 (8%)	48 (26%)
	526 (i-BPPV)	421 (80%)	54 (10%)	4 (0%)	27 (5%)	7 (1%)

Abbreviations: AC, anterior canal; BPPV, benign paroxysmal positional vertigo; HC, horizontal canal; i-BPPV, nontraumatic and idiopathic causes of benign paroxysmal positional vertigo; NOS, not otherwise specified; PC, posterior canal; t-BPPV, posttraumatic benign paroxysmal positional vertigo.

^aA blank cell indicates data are not reported.

^b $P > .05$ for t-BPPV versus i-BPPV multi-canal involvement.

^c $P < .01$ for t-BPPV versus i-BPPV multi-canal involvement.

^d $P = .02$ for t-BPPV versus i-BPPV multi-canal involvement.

as Epley, Semont, Brandt-Daroff and Gans, used as treatment) that this Cochrane review included patients with PC BPPV only.

Discussion

The impression that patients with t-BPPV have more persistent symptoms than patients with i-BPPV has been perpetuated

anecdotally and in a number of texts and publications.^{2,4} However, this systematic review of the literature found that the evidence available does not support this impression.

The overall resolution rate of patients with t-BPPV was found to be 73%. This result is similar, at 71%, even when articles with fewer than 10 patients (5 case reports and 7 case

Table 7. Secondary Outcome: Number of RPMs Required.

Author, y	Group	No.	I RPM/Canal	>I RPM/Canal, No. (%)	P Value >I RPM/Canal t-BPPV vs i-BPPV
Ahn et al, 2011	t-BPPV	32	19	13 -or- 8/22 (36) for PSC ^a 3/7 (43) for HSC ^a	.006 for PSC .024 for HSC
	i-BPPV	105 ^a	94	11 -or- 7/65 (11) for PSC ^a 4/40 (10) for HSC ^a	
Bertholon et al, 2005		3	2	1	
Bockisch et al, 2014		1	1	0	
Cornacchia et al, 2006		1	1	0	
Gordon et al, 2004 ^b	t-BPPV	21	7	14 (67)	.001
	i-BPPV	42	36	6 (14)	
Kim et al, 2013		1	1	0	
Liu et al, 2012	t-BPPV	40	14	26 (65)	.001
	i-BPPV	46	39	7 (15)	
Motin et al, 2005		10	6	4	
Persichetti et al, 2004		1	0	1	
Ralli et al, 2010		2	2	0	
Rodriguez et al, 2007		2	1	1	
Dispenza et al, 2011 ^c	t-BPPV	18	10	8 (44)	NA
	i-BPPV	470	379	91 (19)	
Total for t-BPPV cases		132	64	68	

Abbreviations: HSC, horizontal semicircular canal; i-BPPV, nontraumatic and idiopathic causes of benign paroxysmal positional vertigo; PSC, posterior semicircular canal; RPM, repositioning maneuvers; t-BPPV, posttraumatic benign paroxysmal positional vertigo.

^aPatients with multicanal involvement excluded.

^bControl group in this article was unilateral PSC i-BPPV; t-BPPV group had 4 cases of bilateral PSC-BPPV involvement.

^cControl group here extracted from 2 referenced publications by same author referenced in t-BPPV publication. See footnote in **Table 1** for more details.

series) were excluded. If we further exclude the 1 article that did not specify if RPMs were used, a symptom resolution rate of 67% is calculated for t-BPPV patients treated with canal-specific RPMs. We can compare outcomes of patients with t-BPPV from this systematic review to the group of BPPV patients studied in the 2014 Cochrane review.⁷ In all-comers with BPPV (likely patients with only PC BPPV), symptom resolution rates in the Epley-treated patients were reported to be 56%, and conversion of a positive to a negative DH test was reported to be 80% for Epley-treated patients and 63% for all treatment patients combined. In the majority of our reviewed articles, physical examination was used during follow-up to define success. Thus, the 67% to 73% resolution rates of patients with t-BPPV are most appropriately compared to the 63% to 80% (Epley-all treatment groups combined) DH conversion rate in the Cochrane review. Given that the t-BPPV cohort in this review included cases of HC, AC, and multi-canal BPPV, one would expect outcomes to be significantly worse, if anything, than a group of all-comers with PC BPPV, but this does not appear to be the case. The data on trauma severity in the reviewed articles were not standardized, and a review of the extracted information reveals an inability to draw conclusions with regard to potential effect of trauma severity on outcomes.

The definitive answer to the question of whether or not resolution rates in patients with t-BPPV differ from those in patients with i-BPPV cannot be obtained from the studies included in this review. Some studies support a statistically significant difference in outcomes between the groups, and other studies support the lack of such a difference. Heterogeneity among studies including lack of sufficient information on patient populations studied precluded combining studies, for instance in a meta-analysis. These studies all suffered limitations of bias; all retrospective cohort studies were of poor quality overall.

Although this review does not provide evidence suggesting that symptom resolution rates in patients with t-BPPV and i-BPPV differ significantly, it does suggest that the former have a tendency to present with more multi-canal involvement than patients with non-traumatic BPPV and that patients with t-BPPV seems to require more RPMs for resolution. Thus, although eventual resolution between the 2 groups may not differ, patients with t-BPPV may require more frequent treatment to achieve resolution of symptoms.

In conclusion, the available evidence does not support the notion that patients with t-BPPV have worse resolution rates than i-BPPV cases. However, patients with t-BPPV may more frequently present with multi-canal involvement and may require more frequent RPMs to resolve symptoms. Direct

comparisons between the 2 groups in this systematic review were hindered by low-quality evidence. Well-designed studies of sufficient numbers of affected patients are needed to more accurately address this question.

Author Contributions

Margaret Aronb concept; design of project; data acquisition, interpretation, and analysis; drafting and revision of the article; final approval of version to be published; agrees to be accountable; **Jane Lea**, analysis and interpretation of data, critical review of manuscript, final approval of version to be published, agrees to be accountable; **Doreen Nakku**, data acquisition, critical review article, final approval of version to be published, agrees to be accountable; **Brian D. Westerberg**, conception, design of project, analysis and interpretation of data, critical review of manuscript, final approval of version to be published, agrees to be accountable.

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Supplemental Material

Additional supporting information may be found at <http://otojournal.org/supplemental>.

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