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Analysis of non-posterior canal benign paroxysmal positional vertigo in patients treated using the particle repositioning chair: A large, single-institution series

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ABSTRACT

Purpose: Benign paroxysmal positional vertigo (BPPV) involving the horizontal and superior semicircular canals is difficult to study due to variability in diagnosis. We aim to compare disease, treatment, and outcome characteristics between patients with BPPV of non-posterior semicircular canals (NP-BPPV) and BPPV involving the posterior canal only (P-BPPV) using the particle repositioning chair as a diagnostic and therapeutic tool.

Methods: Retrospective review of patients diagnosed with and treated for BPPV at a high volume otology institution using the particle repositioning chair.

Results: A total of 610 patients with BPPV were identified, 19.0% of whom had NP-BPPV. Patients with NP-BPPV were more likely to have bilateral BPPV (52.6% vs. 27.6%, $p < 0.0005$) and Meniere's disease (12.1% vs. 5.9%, $p = 0.02$) and were more likely to have caloric weakness (40.3% vs. 24.3%, $p = 0.01$). Patients with NP-BPPV required more treatments for BPPV (average 3.4 vs. 2.4, $p = 0.01$) but did not have a significantly different rate of resolution, rate of recurrence, or time to resolution or recurrence than patients with posterior canal BPPV.

Conclusions: Comparison of NP-BPPV and P-BPPV is presented with reliable diagnosis by the particle repositioning chair. NP-BPPV affects 19% of patients with BPPV, and these patients are more likely to have bilateral BPPV and to require more treatment visits but have similar outcomes to those with P-BPPV. NP-BPPV is common and should be part of the differential diagnosis for patients presenting with positional vertigo.

1. Introduction

Benign paroxysmal positional vertigo (BPPV) is a disorder caused by dislodged utricular calcite particles and otolithic membrane fragments sedimenting in the semicircular canals (SCCs), affecting their fluid dynamics [1]. It is the most common cause of peripheral vertigo and has a lifetime prevalence of approximately 2% [2]. Treatment consists of provider-performed canalith repositioning maneuvers, which actively move sediment from the semicircular canals back to the vestibule. These maneuvers confer a 30-fold increase in symptom resolution and improve quality of life [3–5].

Due to gravitational effects, most cases of BPPV result from sedimentation in the posterior SCC[6]. While posterior canal BPPV (P-BPPV) has been recognized for almost 100 years, horizontal canal BPPV (H-BPPV) was first described in 1985 [7] and superior canal BPPV (S-BPPV) soon after. Reported prevalence of these entities varies widely from < 5% to over 40% of BPPV combined [8–10]. This may stem from inter-provider variability in executing diagnostic maneuvers or interpreting nystagmus. Because of this uncertainty, diagnostic and therapeutic data in NP-BPPV is sparse and inconsistent. Prevalence of non-posterior canal BPPV (NP-BPPV) is likely underestimated [11].

Particle repositioning chair (PRC) systems are mechanical chairs which rotate in spherical coordinates to perform canalith repositioning maneuvers. These systems are fitted with goggles for continuous automated monitoring of nystagmus and have unlimited range of motion. They are therefore capable of standardized detection and treatment of BPPV involving any semicircular canal in virtually any patient [12]. While diagnosis of NP-BPPV may vary between providers, PRCs identify involved SCCs consistently and may do so with more accuracy than manual maneuvers.

The purpose of the present study was to analyze factors associated with NP-BPPV in patients who were treated with PRCs at a single, high

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volume otology institution. All patients were diagnosed with BPPV using the PRC, and demographic, diagnostic, and outcome data were collected. We hypothesized that NP-BPPV exhibits unique diagnostic characteristics and different outcomes from P-BPPV which will inform expectations and treatment algorithms for physicians and patients.

2. Methods

2.1. Study design

The records of the Michigan Ear Institute (Farmington Hills, Michigan, USA) were searched for patients treated for BPPV from 2007 and 2017 using a PRC. Diagnosis of BPPV was defined as subjective vertigo and concurrent objective nystagmus elicited by the Dix-Hallpike or another diagnostic maneuver in the setting of a history of positional vertigo. Cases were excluded if these diagnostic criteria were not fulfilled. All data collected were anonymized in compliance with the Health Insurance Portability and Accountability Act of 1996. This work was approved by the Providence-Providence Park Hospital Institutional Review Board.

2.2. Examined variables

Demographic, disease, treatment, and outcome characteristics were recorded and compared between patients with P-BPPV and NP-BPPV. Demographic characteristics included age, gender, and past medical history including Meniere's disease, diabetes mellitus, prior episodes of BPPV, and head trauma preceding BPPV symptoms by one month or less. Meniere's disease was noted if present in any ear.

Disease characteristics included the affected ear(s), affected semicircular canal(s), audiometry, and videonystagmography (VNG) findings. Affected ears and semicircular canals included data from all clinical encounters until either resolution of symptoms or lapse of follow up. Involved semicircular canals were analyzed in exclusive groups of “posterior canal” and “non-posterior canal,” which was further divided into non-exclusive groups of “superior canal,” “horizontal canal,” and “multiple canals,” referring to multiple semicircular canals affected on one side. Three-tone (500 Hz, 1000 Hz, and 2000 Hz) pure tone averages (PTAs) and word recognition scores (WRS) in the ear affected by BPPV were recorded when available; findings from both ears were averaged in cases of bilateral BPPV. PTA was analyzed in groups of normal hearing (0–19 dB hearing loss), mild hearing loss (20–39 dB), moderate hearing loss (40–69 dB), and severe to profound hearing loss (≥70 dB). Caloric weakness in the ear affected by BPPV was recorded from VNG data and divided into groups of normal caloric function (0–24% weakness), mild weakness (25–49%), moderate weakness (50–74%), severe weakness (75–99%), and total weakness (100%).

Treatment and outcome variables included resolution of BPPV, recurrence of BPPV, and treatment visits. Resolution was defined as relief from the majority of symptoms with conversion from a positive to a negative diagnostic maneuver. Recurrence was defined as an episode of BPPV (as defined previously) following resolution. Time from initial visit to resolution and time from resolution to recurrence were recorded in days. Treatment visits were defined as visits during which a particle repositioning maneuver was performed. These were counted from patients' first visits to either resolution of symptoms or lapse of follow up.

2.3. Statistical analysis

All statistical analysis was conducted using SPSS Statistical Software for Windows (IBM, Armonk, New York). Pearson's chi-squared tests were used to determine associations between categorical variables. Student's *t*-tests were used to determine association between patient age and NP-BPPV. Non-parametric tests were used to determine associations between NP-BPPV and non-normal continuous variables, including number of treatment visits, time to resolution, time to recurrence, and audiometric data.

Table 1
Demographic and medical characteristics of patient sample.

Characteristic (n = 610)		Percent
Age	< 40	3.9
	40–59	28.2
	60–79	47.5
	≥80	20.3
Gender	Male	31.6
	Female	68.4
Ear	Left	28.5
	Right	38.9
	Bilateral	32.3
Medical history	Head trauma	10.3
	Diabetes	14.9
	Meniere's disease	7.0
	Prior episodes of BPPV	21.5
Number of treatment visits	1	27.0
	2	37.2
	≥3	35.7
Pure tone average (dB HL)[a]	0–19	56.2
	20–39	28.3
	40–69	14.5
	≥70	1.0
Caloric weakness[b]	Normal (0–24%)	72.7
	Mild (25–49%)	14.8
	Moderate (50–74%)	7.6
	Severe (75–99%)	0.9
	Total (100%)	3.9
Involved canals	Posterior only	81.0
	Horizontal canal	12.6
	Superior canal	6.7
	Multiple canals	6.6
Documented resolution		68.4
Documented recurrence[c]		27.8

[a] As percentage of patients with documented audiometry (n = 502).
[b] As percentage of people with documented caloric testing (n = 330).
[c] As percentage of patients with documented resolution (n = 417).

3. Results

Demographic, disease, and treatment characteristics of 610 patients meeting inclusion criteria are shown in Table 1. Age ranged from 12 to 98 years with average age of 66.5 years, and 68.4% of patients were female. NP-BPPV affected 19.0% of patients; 12.6% of patients had horizontal canalithiasis, 6.7% had superior canalithiasis, and 6.6% had multiple canalithiasis. Bilateral BPPV was present in 32.3% of patients. Distribution of involved semicircular canals is shown in Fig. 1. Overall rate of resolution was 68.4% and rate of recurrence was 27.8%.

Comparison of demographic, disease and treatment variables between patients with P-BPPV and NP-BPPV is shown in Table 2. Patients with NP-BPPV were more likely to have bilateral BPPV (52.6% vs. 27.6%, $p < 0.0005$). No significant differences were noted in age, gender, or history of head trauma, diabetes, or prior BPPV episodes between the two groups. Meniere's disease was more prevalent in the NP-BPPV group (12.1% vs. 5.9%, $p = 0.02$). Patients with NP-BPPV were more likely to have pathologic caloric weakness (40.3% vs. 24.3%, $p = 0.01$). This relationship was conserved when independently comparing superior canal BPPV (47.4% vs. 24.3%, $p = 0.03$) and horizontal canal BPPV (38.1% vs. 24.3%, $p = 0.05$) to P-BPPV.

Median time to resolution was 64 days and median time to recurrence was 265 days. Mean and median number of treatment visits prior to resolution were 2.6 and 2.0 visits, respectively. Comparison of outcome characteristics between patients with P-BPPV and those with NP-BPPV is shown in Table 3. There were no significant differences in the documented rates of resolution or recurrence or in time to resolution or recurrence between P-BPPV and NP-BPPV. Patients with NP-BPPV