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# Epidemiology of benign paroxysmal positional vertigo (BPPV) and risk factors for secondary BPPV: a population-based study

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## Abstract

**Background** BPPV (benign paroxysmal positional vertigo) is a disorder that causes sudden, spinning sensation for few seconds with specific head movements. Of all disorders of inner ear that causes dizziness, BPPV is the most common one. To understand this disorder, we conducted a retrospective study at a tertiary care ENT hospital in Eastern India.

### Aims and objectives

1. To know the incidence of BPPV among all vertigo patients.
2. To know the age-sex distribution of BPPV.
3. To identify secondary causes of BPPV and their prevalence.
4. To know the incidence of different canal BPPVs.
5. To ascertain the treatment outcome of different particle repositioning maneuvers in BPPV.

**Methods** Total 575 patients presented to the vertigo clinic from 15 September 2018 to 21 March 2022. Out of them 151 patients (26.6%) were diagnosed with BPPV by proper history taking, clinical examination including provocative tests. They were treated with appropriate particle repositioning maneuvers (PRM). Patients were followed for mean 6 months and results were analyzed.

**Results and analysis** Of all vertigo patients, BPPV constitutes 26.6% of cases, making it most common cause of peripheral vertigo. It commonly affects 40–60 years of age group with equal sex predilection. Eighty-three percent of cases were idiopathic, secondary causes include vestibular migraine, Meniere's disease, labyrinthitis, and orthostatic hypotension. Posterior canal was most commonly affected (74%), followed by lateral and anterior canal. Particle repositioning maneuver (PRM) cures 96% of all BPPV patients (75% needs only one PRM, 15% requires the second one) with overall success rate of 96% after 6 months of follow-up.

**Conclusion** BPPV is the most common cause of peripheral vertigo. One has to understand the anatomy, physiology and pathophysiology of vestibular system to provide better patient care in these patients. Particle repositioning maneuver (PRM) is the treatment for BPPV.

**Keywords** Benign paroxysmal positional vertigo (BPPV), Dix-Hallpike maneuvers, Particle repositioning maneuver (PRM), Epley's maneuver

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## Background

BPPV is the most common peripheral vestibular disorder. It is caused either by free floating particles in the semi-circular canal (canalithiasis) or by deposition of particles on the cupula of the semicircular canals (cupulolithiasis).



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It manifests as sudden, short lived true spinning sensation on particular head movements like, getting up from bed, extending the neck to drink water from a bottle or picking up an object from floor.

All three canals can be affected but posterior canal is the commonest to be involved, followed by lateral canal and anterior canal is the rarest.

BPPV is diagnosed by provocative tests like Dix-Hallpike for posterior canal, supine roll over for lateral canal, and deep head hanging for anterior canal.

The majority of patients is treated successfully by particle repositioning maneuvers (PRM). Commonly performed PRMs are Epley's maneuver for posterior canal BPPV, barbecue maneuver for lateral canal BPPV, and Yacovino maneuver for anterior canal BPPV.

A small percentage of posterior canal BPPV who recurs after conservative management may be managed surgically by singular neurectomy or plugging of posterior semicircular canal.

### Anatomy and physiology

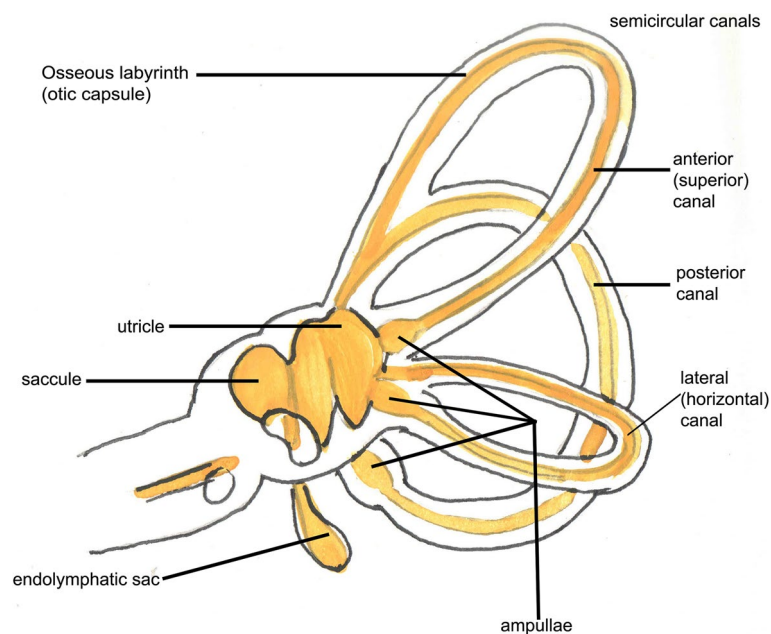
To understand BPPV, it is important to know the anatomy, physiology and pathophysiology of vestibular system. Each vestibular system comprises of five distinct apparatus—two Otolith organs, utricle, and saccule for linear acceleration; three semicircular canals for angular acceleration (Fig. 1). Each semicircular canal contains an arm called crura which terminates in a dilated end called ampulla. It contains endolymph. Within the ampulla there is cupula, a gelatinous mass of same density as

endolymph. There are hair cells at the base of cupula. Angular movement in the plane of a semicircular canal moves the endolymph into the opposite direction due to fluid inertia. This moves the cupula in the direction of the endolymph which in turn displaced cilia of the hair cells placed in the base of cupula. This results either in excitation or inhibition depending on the direction of ciliary movement, and also on which semicircular canal being stimulated. In case of posterior and superior canals, utriculofugal deflection of cupula is excitatory and utriculopetal deflection is inhibitory. The reverse is true for lateral canals.

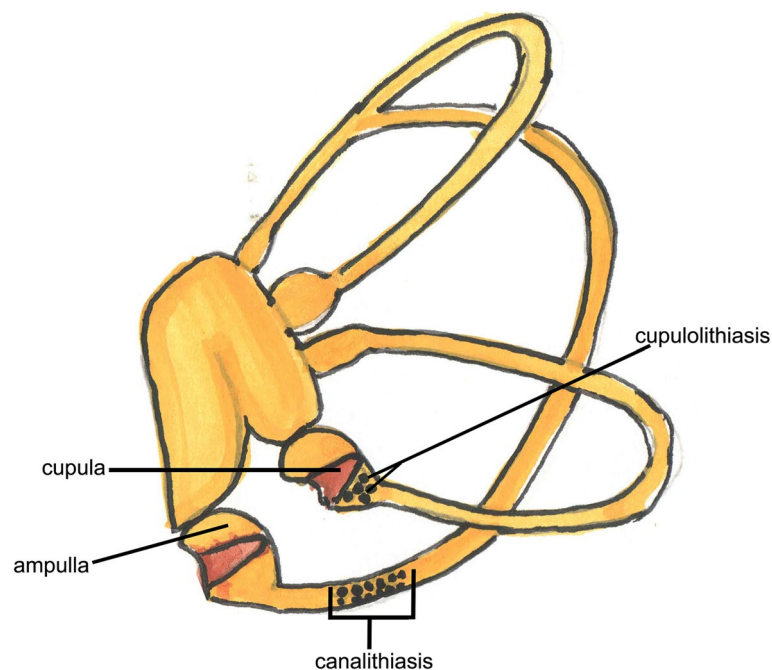
### Pathophysiology

BPPV is caused by two mechanism—canalithiasis and cupulolithiasis (Fig. 2). Canalithiasis describes free floating particles within the semicircular canal. These particles are degenerated otoconia which are made up of otoconia proteins like Oc90, otolin, SC1, which binds with Calcium carbonate. They are crystalline structure with triangular in cross section. Different causes that lead to its degenerations are age, ototoxicity, trauma etc. Hall, Ruby, and McClure [1] first described this theory in 1979. It is now known to be major mechanism of all subtypes of BPPV.

In 1992, Parnes and McClure [2] confirmed this theory during posterior canal occlusion surgery where they microphotographed free floating otoconia particles within posterior canal endolymph. The cupula is impermeable and acts as barrier for these particles.



**Fig. 1** Hand drawing of bony and membranous labyrinth



**Fig. 2** Hand drawing of concept of canalithiasis and cupulolithiasis

So, the non ampulated ends (crus commune end and non ampulated end of lateral canal) are only entry and exit points for these particles. After close observation of the orientation of semicircular canals, one can infer that particles can reach posterior canal easily due to its gravitational pull. But it is difficult to enter the superior canal as its antigravity movement.

The term cupulolithiasis describes particles deposition onto the cupula. This theory was first proposed by Schuknecht [3] in 1968 and thought to play a more significant role in lateral canal BPPV.

## Methods

This is a retrospective study done at Tertiary vertigo centre in eastern India from 15 September 2018 to 21 March 2022—total 3.5 years duration with mean follow-up of 6 months. Total 575 patients presented to the vertigo clinic. After proper history taking clinical examination, otological examination including Dix-Hallpike, supine roll over, deep head hanging test; 151 patients were diagnosed with BPPV, thus BPPV represents 26.26% of all vertigo patients, making its most common cause of peripheral vertigo. All patients underwent video nystagmography, dynamic visual acuity, subjective visual vertical, craniocorpography, and cerebellar tests to rule out other causes of vertigo and also for documentation.

## Description of common tests and maneuvers that were performed in this study

### A. Dix-Hallpike test

1. Make the patient sit on examination table, such that the shoulders would level on the edge of table when lying down.
2. Always start the examination with the ear that is least suspected
3. Turn the patient's head to 45° towards the test ear, by holding the both sides of the patient's head with your hands.
4. Instruct the patient to fix his/her eyes on a point directly in front of him/her and keep the eyes open throughout the test.
5. Patient lies back quickly from a sitting to supine position, with the head hanging 30° off the end of the examination table.
6. Observe for nystagmus, vertiginous symptoms in this position for 30 s.
7. Then the patient returns to the upright position and is observed for nystagmus and vertiginous symptoms for 30 s.
8. Repeat the entire manoeuvre with the head turned 45° toward the opposite side after few minutes.

**Typical nystagmus in Rt posterior canal BPPV**

In head down position, an up-beating, torsional nystagmus towards right side starting after few seconds of latency was noted and it stopped after few seconds. When the patient was returned to upright position a milder down-beating torsional nystagmus towards right was noted.

**B. Supine roll test**

A person is brought from sitting to a supine position, with the head turned 90° to one side and flexed about 20° forward by putting a pillow under his head. Once supine, the eyes are typically observed for about 30 s. The head is then rotated to the midline for 30 s, and then 90° to the

other side. Eyes were observed for horizontal nystagmus towards the opposite side of head rotation. Geotropic (jerking downwards) nystagmus was more common than ageotropic (jerking upwards) in lateral canal BPPV. The side having more intense horizontal nystagmus is the affected side.

**C. Deep head hanging test**

The patient is brought from sitting to supine position with head hanging 30°. Clinically, anterior canal-BPPV is characterized by a vertical downbeat nystagmus with a torsional component toward the affected side when the individual is looking straight ahead in this position.



**Fig. 3** Demonstration of Epley's maneuver

D. Epley’s maneuver (Fig. 3)

After confirming the diagnosis by Dix-Hallpike test, the patient was brought from sitting position (position 1) to supine head down (30° by putting a pillow under the shoulder) and head rotated towards the affected side (say left side) (position 2). He was kept in this position for 1 min or till nystagmus stopped, now his head was rotated 90° to the opposite side (here towards right) and again kept for 1 min (position 3). Now he was assisted to rotate the whole body towards right so that his nose points towards the floor (position 4) and kept for 1 min.

Now he was brought back to sitting position (position 1). Now Dix-Hallpike maneuver is repeated and normally there is no torsional nystagmus suggesting resolution of BPPV. If there is torsional nystagmus, Epley’s maneuver is repeated once. The patient was instructed to sleep on the opposite side with slight head up and was asked to consciously avoid provocative positions for at least 2 weeks.

E. Barbeque maneuver (Fig. 4)

After confirming the diagnosis, the patient is brought to supine position and head rotated to the affected side



**Fig. 4** Demonstration of Barbeque maneuver

(say left) (position 1) and kept for 1 min, now he was rotated 90° (position 2) and was asked to rotate his head further 90° to right (position 3), now he was asked to sleep on his belly with chin touching his chest (position 4) and maintained for 1 min, now he was rotated to right side 90° (position 5) and asked to maintain for 1 min (position 3). Now he was returned to upright sitting position (position 6).

F. Yacovino maneuver (Fig. 5)

After diagnosis is confirmed by deep head hanging test, the patient was brought from sitting (position 1) to supine with head down 30° (position 2) and was maintained in this position for 30 s. Now neck was flexed so that his chin would touch his chest (position 3) and

kept in this position for 30 s and now returned to sitting position (position 4).

**Results**

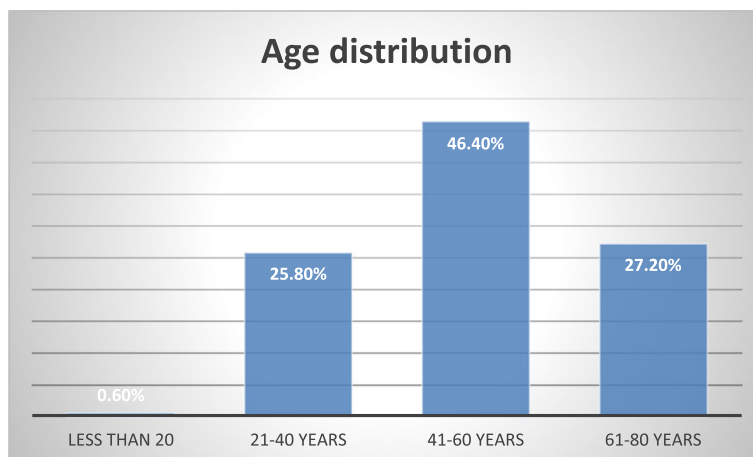
Male: Female: 51%: 49% = 1:1 both sexes are equally affected by BPPV.

All age groups were affected but 41–60 years was most commonly affected (70%), particularly 51–60 years, followed by 61–80 years. BPPV was not common in less than 20 years (Fig. 6).

No definite cause could be ascertained in 83.4% of BPPV cases whereas secondary causes were found in 16.6% cases. Among different secondary causes, vestibular migraine was found in 15.8%, orthostatic hypotension (24%), Meniere’s disease (8%) labyrinthitis [4] central vestibulopathy (4%) were found (Fig. 7). BPPV in Meniere’s disease differs from that of idiopathic BPPV in the sense (a) duration of symptoms is longer, (b) caloric

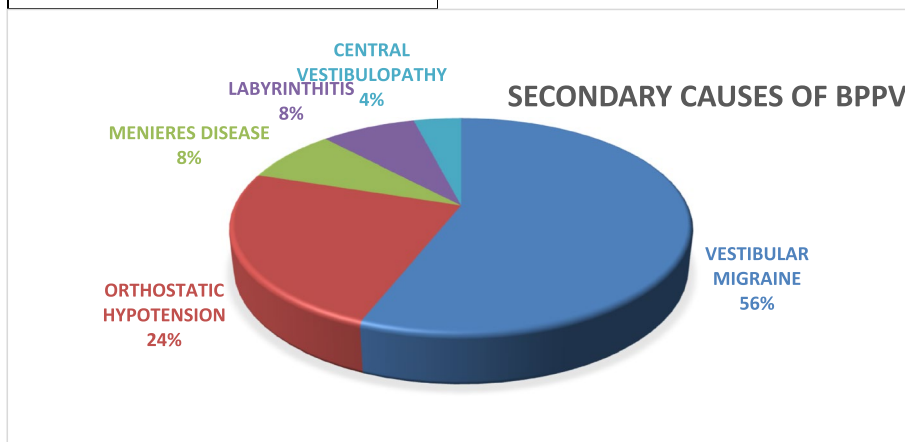


**Fig. 5** Demonstration of Yacovino maneuver



**Fig. 6** Age distribution of BPPV patients

IDIOPATHIC CAUSES 126/151= 83.3%  
 SECONDARY CAUSES 25/151= 16.7%



**Fig. 7** Causes of BPPV

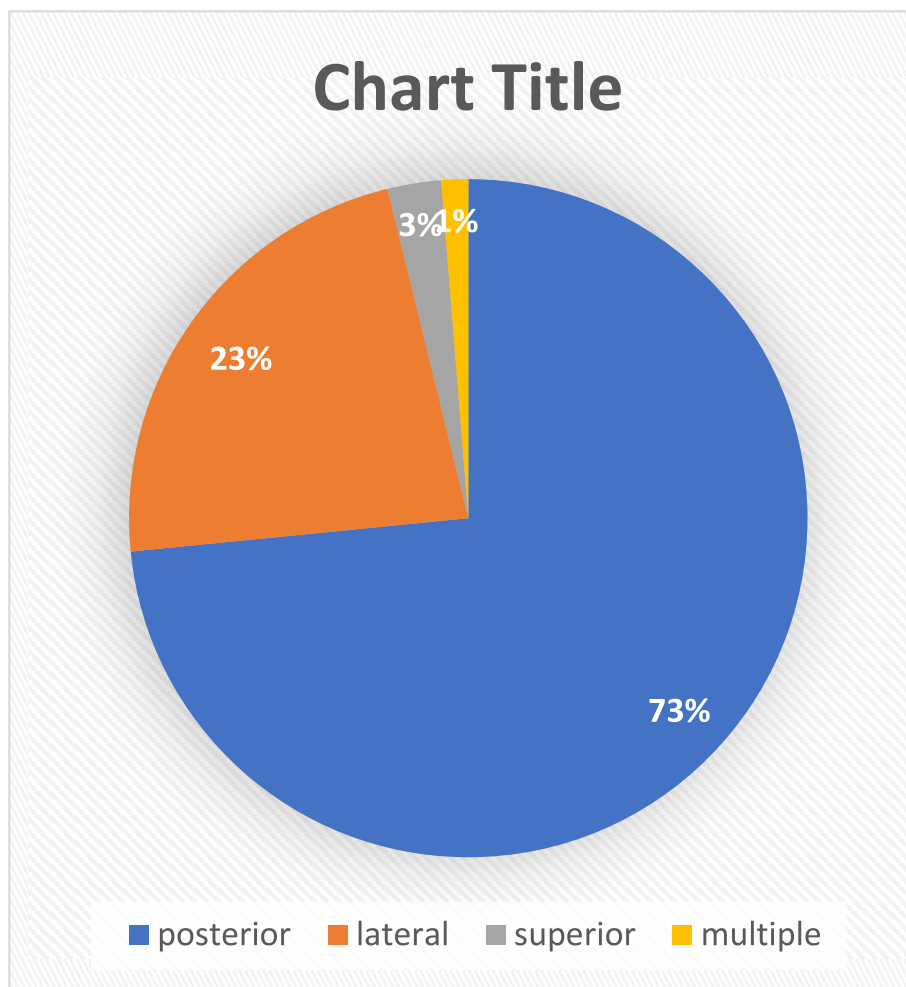
canal paresis is more frequent, (c) treatment outcome is poorer, and (d) recurrence rate is higher (Taura A, Funabiki K, Ohgita H, Ogino E, torii H, Matsunaga M, Ito J. One third of vertiginous episodes during the follow-up period are caused by benign paroxysmal positional vertigo in patients with Menier’s disease. *Acta Otolaryngol.* 2014;134(11):1140–5).

About 15% of recurrent BPPV patients suffer from migraine headaches. The high comorbidity of MH in our recurrent BPPV cohort may suggest that recurrent BPPV has a relationship with migraine. Recurrent BPPV may potentially be a manifestation of migraine in the inner ear, which we term vestibular migraine.

Orthostatic hypotension was found in certain cases of BPPV. It is reasonable to hypothesize that OH plays a role in the genesis of orthostatic dizziness that patients commonly experience after recovery from BPPV.

Few patients presented with BPPV within 3 months of onset of vestibular neuritis. In this subset of patients multiple PRMs were needed and had higher incidence of recurrence.

74.9% cases were due to posterior canal involvement, 23.2% were of lateral canal and 2.6% were due to superior canal involvement. Multiple canal involvement and canal conversion was noticed in 1.3% case. In posterior canal, 55% cases were of right side and cupulolithiasis was



**Fig. 8** Percentage of canal involvement

noted in one case. Whereas in lateral canal mostly was in left side and 20% were due to cupulolithiasis (Fig. 8).

BPPV was treated with PRM (particle repositioning movement)—modified Epley for posterior canal, barbeque for lateral canal, and Yacovini for superior canal. After PRM we routinely repeat provocative test immediately and look for any torsional nystagmus and asked for any true spinning sensation. Negative provocative test and no vertigo considered as successful treatment. They were advised not to sleep on the affected side for 3 days and avoid provocative positions like hyperextension of neck for one week. Mild anxiolytic drug was advised for a week. If provocative rests became positive and patient had true spinning sensation, PRM was repeated. If no vertiginous sensation noticed within 6 months of PRM, we conclude them as completed treatment. If three or more PRMs fail to provide relief and patient complained of spinning sensation, we conclude them as “Treatment

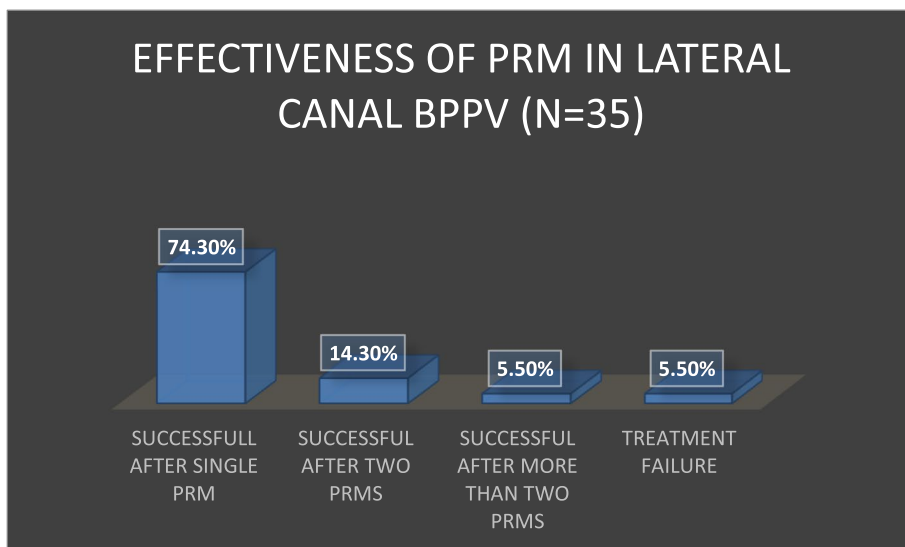
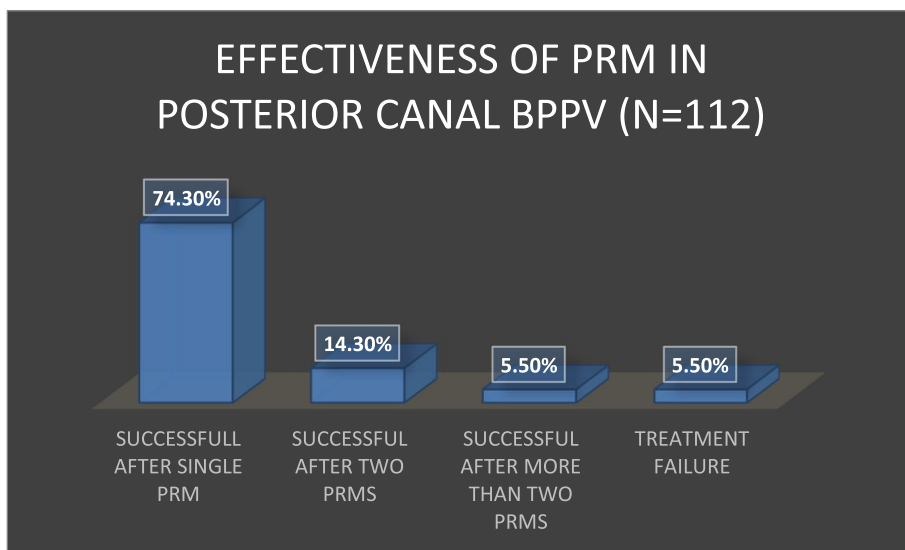
failure” and they are subjected to further neuro-imaging to rule out neurological disorder. If 3 or more attacks of BPPV were noticed within 6 months of successful PRM, we termed them as “Recurrent BPPV”. Brandt-Doroff home exercises were prescribed to these patients with Betahistine hydrochloride (72 mg/day in adult) and anxiolytic for 3 weeks as recurrent BPPV is highly associated with Meniere’s disease where betahistine hydrochloride is a treatment of choice.

**Results of treatment: (Fig. 9)**

**Treatment results in posterior canal BPPV (n = 112)**

77.6% patients were cured after first Epley’s maneuver. Further 15.1% and 3.5% were relieved of symptoms after two and more than two Epley’s maneuver respectively. Only 3.5% had treatment failure.





SUCCESSFULL AFTER SINGLE PRM	4	100%
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**Fig. 9** Results of treatment (results of particle repositioning manuever in different canals)

**Treatment results of lateral canal BPPV (n = 35)**  
 74.3% were successfully treated after single Barbeque roll over maneuver, 5.5% had treatment failure. Treatment results in superior canal BPPV (n = 4)—all were treated successfully after single PRM.

Different causes noticed in cases of treatment failure (n = 6) like central vestibulopathy, vestibular migraine, Meniere’s spectrum disorder, and brain tumors.

## Discussion

Barany first described it in 1921. He described the attacks of this disorder as “The strong rotatory nystagmus to the right. The attack lasted about 30 s and was accompanied by violent vertigo and nausea. If, immediately after the cessation of these symptoms, the head was again turned to the right no attack occurred, and in order to evoke a new attack in this way, the patient had to lie for some time on her back or left side.” Since the initial description of this disorder there has been tremendous research in the field of vestibulology.

Brevern et al. [5] reported lifetime prevalence of BPPV at 2.4% and females are found to be more affected than male. But in our study male and female were equally affected. According to Hilton M [6] study the commonest age of onset was found to be fifth to seventh decade and this is corroborated with our study. Katsarkas [7] found that 50–70% cases of BPPV were to be idiopathic and among secondary causes trauma, viral labyrinthitis, Meniere’s disease, migraine, iatrogenic causes were important. In our study, 83.4% cases were idiopathic in nature and secondary causes are also similar to this study.

Studies [8] have suggested 10–15% incidence of lateral canal BPPV, in our study we found lateral canal BPPV constitutes 23.2% of all cases; whereas superior canal constitutes 2.6% in accordance with world literature [4, 7]. The modified Epley’s maneuver successfully treated 72% after single attempt [9]. In our study, we found that 77.6% patients were cured after single attempt of PRM. In a study of 14 patients with superior canal BPPV, it was found that the vertiginous symptoms resolved rapidly after PRM [10]. In our study, 4 patients with superior canal BPPV were treated successfully after single attempt of PRM. The effectiveness of Barbeque Roll PRM in lateral canal is approximately 75% (range 50–100%) [8]. In our study, the effectiveness as 74.3%, i.e., comparable with other literature.

## Controversy

Though several studies recommend use of mastoid vibrator for Epley’s maneuver but more recent studies show the rate of success is similar in both cases; hence, it is not recommended now-a-days. In our study, we have not used mastoid vibrator for PRMs. Though some studies [11] suggest post PRM instructions were not important, but we found that these instructions definitely reduce chance of recurrence after PRM. Another area of controversy is how many times PRM should be done in one session. Review of literature showed, the number of PRMs does not affect short term effectiveness or long-term recurrences. In our study repeat PRM in the first setting

was reserved for those patients who had severe vertigo and torsional nystagmus during repeat Dix-Hallpike or other provocative tests.

## Conclusion

This is a large retrospective study exclusively on BPPV carried out in India, which concludes.

- BPPV constitutes, 26% of all vertigo patients.
- Idiopathic in 83% of patients; secondary causes include vestibular migraine, Meniere’s disease, labyrinthitis, and orthostatic hypotension. Secondary BPPVs were usually recurrent, refractory to PRMs and took longer time to be treated.
- Male and female are equally affected and commonest in 40–60 years age group.
- Posterior canal BPPV comprises 74% of all BPPV patients, followed by lateral and superior canal is least affected.
- Provocative tests are accurate, reproducible to locate the site and side of lesion.
- Particle repositioning maneuver (PRM) cures 96% of all BPPV patients, 75% needs only one PRM, 15% requires the second one.
- Success rate of this PRM is 96% after 6 months of follow-up.

## Acknowledgements

We acknowledge the help of the hospital authority in conducting this study. The study has not done any harm to animals and the human beings. We do hereby give the consent for publication.

## Authors’ contributions

AG has conducted the study, SD is responsible for compiling and statistical analysis of the data. Both authors read and approved the final manuscript.

## Funding

There is no funding from any company or agency in whatsoever form and there is no conflict of interest or competing interests.

## Availability of data and materials

All data are available with the corresponding author and will be shared with request.

## Declarations

### Ethics approval and consent to participate

We, the authors, do hereby affirm that this study have been carried out with compliance with Ethical Standards of this Hospital. The “Hope Nursing Home Ethical Committee” comprising of the Chairman, hospital administration; Chairman, education and research committee and chairman, hospital regulatory committee gave consent and approved this study (Approval No. HNH /209/2022) named “Epidemiology of Benign Paroxysmal Positional Vertigo (Bppv) & Risk Factors For Secondary Bppv: A Population Based Study.” Informed written consent to participate in this study was obtained by all participants.

### Consent for publication

All participants of this study had given written consent to publish their image and medical data for publication in medical journal.

### Competing interests

The authors declare that they have no competing interests.

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