The Journal of International Advanced Otology

J Int Adv Otol 2022; 18(6): 513-521 • DOI: 10.5152/iao.2022.21629

Original Article

Incidence of Benign Paroxysmal Positional Vertigo and Course of Treatment Following Mild Head Trauma—Is It Worth Looking For?

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Cite this article as: Jensen JK, Hougaard DD. Incidence of benign paroxysmal positional vertigo and course of treatment following mild head trauma—Is it worth looking for? *J Int Adv Otol.* 2022;18(6):513-521.

BACKGROUND: This study aimed to identify the incidence of benign paroxysmal positional vertigo following head trauma.

METHODS: This study is a prospective cross-sectional study. Initially, a targeted search for the identification of patients with the international classification of diseases (ICD-10) diagnosis of cerebral commotio at relevant emergency units in the Northern Region of Denmark was done. This was followed by a clinical examination to determine the incidence of benign paroxysmal positional vertigo (BPPV) within this population. Of the 295 patients diagnosed with commotio cerebri during a 4-and-a-half month period, 85 patients were included. All patients underwent clinical examination in a mechanical repositional chair wearing Video Frenzel Goggles. Additional examinations included a complete video head impulse test.

RESULTS: A total of six patients were identified with benign paroxysmal positional vertigo (BPPV) following minor head trauma. Bilateral BPPV, multicanal BPPV, and BPPV of a single semicircular canal were identified. All patients experienced relief of benign paroxysmal positional vertigo-related symptoms within 3 treatment sessions. Five patients were identified with a pathological video head impulse test, 54 with an inconclusive examination, and 15 with a normal video head impulse test.

CONCLUSION: The incidence of benign paroxysmal positional vertigo following minor head trauma was 7%. A relatively high number of atypical subtypes of benign paroxysmal positional vertigo was found. When applying strict criteria for the interpretation of video head impulse test examination, the number of patients with inconclusive video head impulse test examination was higher than expected and 6.7% of patients had a pathological video head impulse test examination. No relationship between benign paroxysmal positional vertigo and pathological video head impulse test was observed.

KEYWORDS: Benign paroxysmal positional vertigo, BPPV, secondary benign paroxysmal positional vertigo, video head impulse test, vHIT, mechanical repositional chair

INTRODUCTION

Benign paroxysmal positional vertigo (BPPV) is defined by recurrent attacks of transient vertigo or positional dizziness provoked by changes in the position of the head accompanied by characteristic positional nystagmus.[1-3] The most common cause of BPPV is idiopathic BPPV, also termed primary BPPV.[1] Head trauma has been identified as one of the major causes of secondary BPPV.[2,4]

Two theories describe the pathophysiology of BPPV: canalolithiasis (CAN) and cupulolithiasis (CUP). Both theories describe the condition where dislodged otoconia from the otolithic macula bed have been trapped in one or several of the semicircular canals (SCCs). Canalolithiasis describes the condition with free-floating otoconia within the lumen of the SCC,[3,5] whereas CUP refers to the condition where particles adhere to the cupula, thereby causing a false perception of movement.[6]

Benign paroxysmal positional vertigo is diagnosed by positional testing with the Dix–Hallpike (DH) test and/or the supine roll test (SRT).

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Received: December 13, 2021 • **Accepted:** February 20, 2022 • **Publication Date:** November 1, 2022
Available online at www.advancedotology.org

The posterior SCC is the most common SCC to be affected by BPPV, followed by the lateral and anterior SCCs.[7] In contrast to idiopathic BPPV, traumatic BPPV is more likely to involve multiple SCCs or induce bilateral affection,[8-13] has lower resolution rates, and is more likely to reoccur.[14]

Normally, the repositioning maneuvers are conducted on an examination bed, but mechanical repositioning chairs (MRCs) may be used as well. Addition of videonystagmography (VNG) allows for more precise diagnostics and provides objective measurements of the nystagmus (direction, velocity), thereby increasing the diagnostic accuracy and effectiveness of the treatment provided subsequently.[7] The MRC can be rotated and locked in intervals of 45° in the yaw plane before tilting the chair forward or backward in the pitch plane, allowing the addition of kinetic forces to the treatment. Pedersen et al[15] achieved successful treatment of 92.4% of patients with very intractable BPPV with an average of 2.23 treatments with this chair.

One way of examining the vestibular function is by means of the video head impulse test (vHIT).[16] With vHIT, the examiner tests the vestibular ocular reflex (VOR).[17] Complete vHIT allows the detection of any vestibular damage to each of the SCCs individually or to one or both vestibular nerve(s) bilaterally.

Benign paroxysmal positional vertigo causes a subjective feeling of vertigo, which some patients describe as dizziness. The subjective consequences of vestibular hypofunction can be quantified by the 25-item Dizziness Handicap Inventory (DHI) questionnaire. The DHI is a tool to assess the self-perceived quality of life effects of diseases related to the vestibular system.[18]

METHODS

During a four-and-a-half-month period, 295 patients, aged 18 years or older, were diagnosed with a concussion (minor head injury) at one of the Emergency Departments (EDs) in the Northern Region of Denmark. A total of 85 patients were included and 210 were excluded for various reasons (see Figure 1). No patients were excluded because of impaired hearing and/or tinnitus.

In total, 79 patients did not present with neither objective findings nor subjective symptoms related to BPPV in any of the 6 SCCs, and six patients received a diagnosis of BPPV.

MAIN POINTS

- The incidence of benign paroxysmal positional vertigo (BPPV) following mild head trauma is 7% with the Bárany Society diagnostic criteria.
- 50% of the patients with BPPV had affection of multiple semicircular canals.
- In average, patients needed 2 treatments in the mechanical repositioning chairs for complete resolution.
- Complete video head impulse test (vHIT) examination found 5 participants (6.7%) with a pathological vHIT and 54 participants (72.9%) with an inconclusive vHIT examination. No studies with the same diagnostic criteria have reported results on this.
- All patients with BPPV reported better self-perceived quality of life following the treatment of BPPV.

All patients were diagnosed and treated for BPPV with the mechanical TRV repositioning chair (Interacoustics©, Middelfart, Denmark) combined with VNG (VF405®, Interacoustics©, Middelfart, Denmark, OtoAccess version 1.0.2448.22383)

Diagnostic criteria from the Barany Society were used. This included the DH maneuver, which was used to test for BPPV of the posterior and anterior SCCs, as well as the subtypes CAN and CUP.[3] The SRT was used to test for CAN and CUP subtypes of BPPV within the lateral SCCs. An accompanying geotropic or apogeotropic positional nystagmus with concomitant vertiginous symptoms during the SRT was used to define BPPV in one of the lateral SCCs. Benign paroxysmal positional vertigo in one of the lateral SCCs was also subcategorized into CAN or CUP. Canalolithiasis was diagnosed if a bilateral geotropic positional nystagmus during the SRT was observed with accompanying symptoms of vertigo. The position (side) with the highest average slow phase velocity (aSPV) of the positional nystagmus defined the affected side. If bilateral apogeotropic positional nystagmus was observed during the SRT, a BPPV subtype of CUP was diagnosed. In this BPPV subtype, the position (side) with the lowest aSPV of the positional nystagmus defined the affected side.

Patients diagnosed with BPPV underwent treatment with MRC according to the clinical guidelines of the North Denmark Region.

For treatment of posterior and lateral BPPV, see Figures 2 and 3.

If the patient could not cooperate to the treatment with impulses, the dynamic barbeque roll was performed. With this maneuver, the patient was tilted 90° backward to the supine position. The patient was then rotated 90° toward the affected side. From this position, the patient was rotated 360° toward the unaffected side ten times. Every rotation included a powerful acceleration and deacceleration phase. Following the final rotation, the patient was rotated 45° toward the affected side and the rotation was stopped.

Treatment of anterior BPPV was done with the deep head hanging (DHH) maneuver. With the DHH maneuver, patients received 10 impulses after a 135° forward tilt followed by 20-30 seconds pause at a total tilt of 180°. Finally, the patients received 10 impulses at a 270° tilt, before being repositioned to the upright position by rotating the last 90°. If the patient could not cooperate with treatment with impulses, the maneuver was performed without the addition of kinetic forces.

Patients diagnosed with BPPV were scheduled for a follow-up examination. Successful treatment was defined as complete remission of both vertiginous symptoms and positional nystagmus. If the initial treatment was not completely successful, the patient underwent additional BPPV treatment(s) until complete remission was observed. If a patient was diagnosed with multicanal BPPV or bilateral BPPV, the most severely affected SCC was treated first. The order of treatment was determined by the highest aSPV and the most symptomatic SCC during testing (often coexisting).

All patients, if capable, also underwent a complete vHIT examination of all 3 paired SCCs.

The patient's ability to cooperate was assessed prior to vHIT testing. Patients either incapable of fixating on a target 1 meter away,

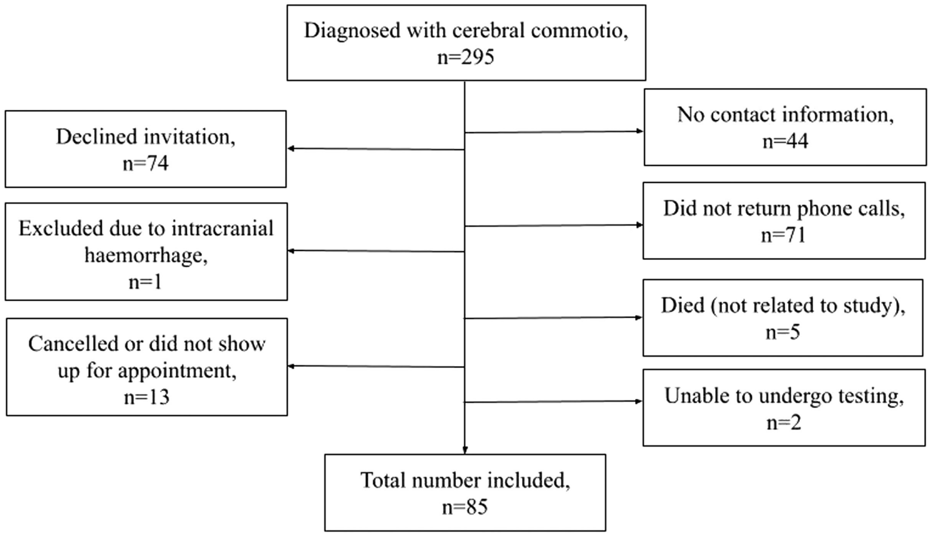

Figure 1. Trial profile.

suffering from eye muscle palsies or previous meningitis, or with a history of neck surgery or cervical herniation were excluded.

To ensure that the inflicted head impulses evaluated the vestibular function (and not other oculomotor control systems), head impulses were fast, abrupt, and unpredictable (both timing and direction), with high velocity and with small amplitude.[16,17]

The vHIT was performed with ICS impulse® (Otometrics©, Høje Taastrup, Denmark). The test was performed with the same setting every time. The vHIT goggles were tightly fitted, and calibration was performed according to the manufacturer's recommendations. Every SCC was examined with 15 successive head impulses following the procedure as described by Hougaard and Abrahamsen.[16] Following standard test procedures, the software (OTOsuiteV version 4.1) calculated a mean gain value describing the ratio between the peak eye and peak head velocities for each SCC. Area under the curve was used to calculate the mean gain value. Based on the vHIT results, the subjects were divided into 3 groups: normal, pathological, and inconclusive (grey zone). The latter was further divided into 2 groups with either normal mean gain values with concomitant pathological saccades or low mean gain values with no concomitant pathological saccades. For further description, refer to Table 1.[19] Finally, if patients were diagnosed with BPPV, pre- and post-treatment DHI

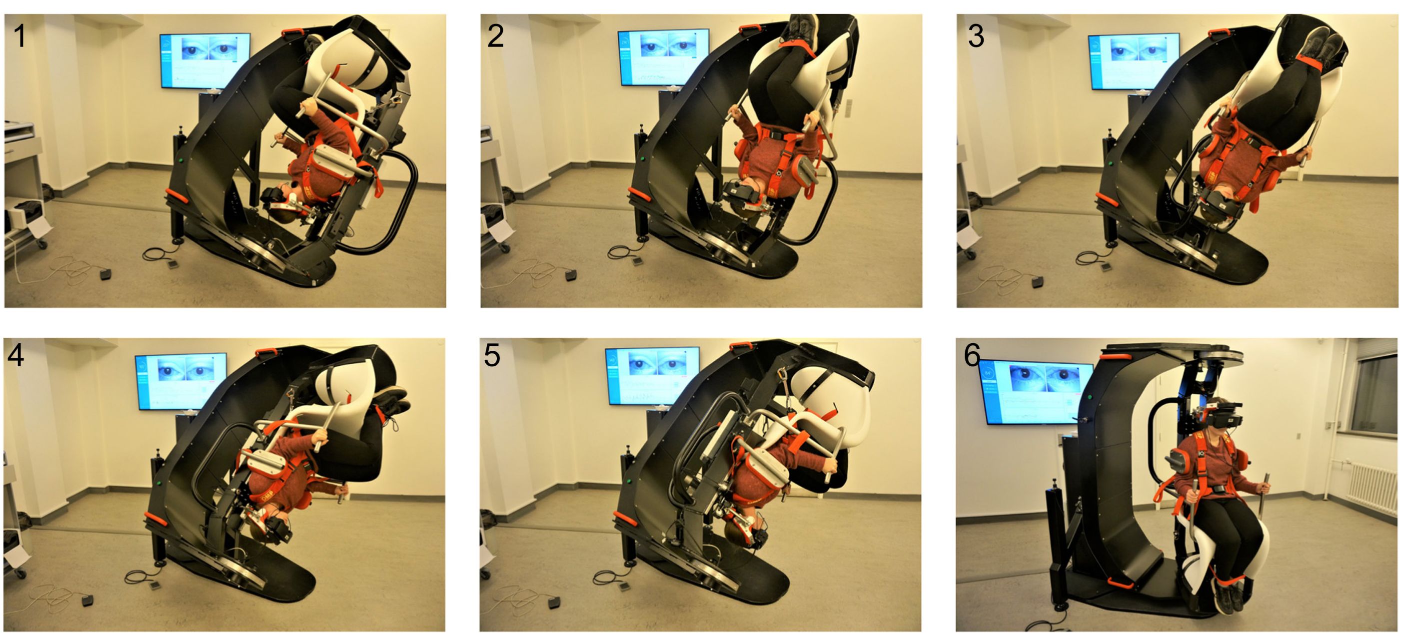

Figure 2. Treatment of left posterior benign paroxysmal positional vertigo with the mechanical rotational chair (MRC) (1-6). With the potentiated Epley maneuver, kinetic forces (impulses) were added in 5 separate positions (1-5. Initial position was the Dix-Hallpike position (1)). During the continued repositioning, the patient was rotated 45° toward the unaffected side 4 times (180° in total) (2-5). The final step of the repositioning maneuver was returning the patient to the upright position (6). If the patient was unable to comply with the procedures included in the potentiated Epley maneuver, instead a standard Epley maneuver was performed with the mechanical rotational chair. Please note that video Frenzel goggles together with video nystagmography equipment were added to optimize the diagnostic procedures and treatment sessions with the MRC.

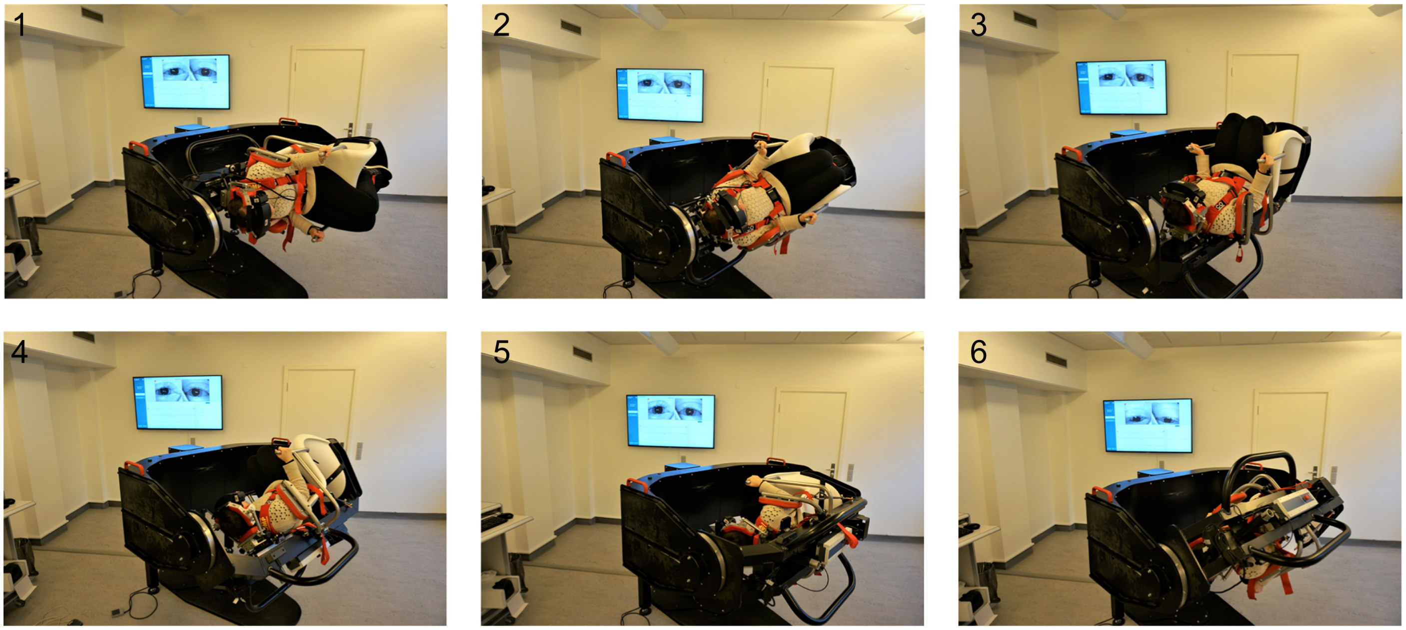

Figure 3. Treatment of right lateral benign paroxysmal positional vertigo with the mechanical rotational chair (1-6). For the treatment of cupulolithiasis, the patient was placed in the supine position and rotated 90° toward the affected side. Ten impulses were given in 6 separate positions where the patient was rotated 45° toward the unaffected side with every change in position (1-6). The final position (6) was held for 30-60 seconds after which the patient was returned to the upright position. For treatment of canalolithiasis. the patient was rotated 45° toward the affected side. Afterward, the chair was tilted 90° backward (2). Patients would then receive 10 impulses in the following 5 positions (2-6). The positions were separated by a 45° rotation of the patient toward the unaffected side. The final position (6) was held for 30-60 seconds, after which the patient was returned to the upright position.

questionnaire scores were collected. The score was calculated by the number of questions answered with a "yes" or "sometimes" providing 4 or 2 points, respectively, with a maximum total score of 100 points. Questions that answered "no" were given 0 points. Based on the total DHI score, the patients were allocated into 4 groups: no handicap (0-14), mild (15-26), moderate (27-44), and severe (44+), as proposed by McCaslin.[20]

Table 1. Classification of Video Head Impulse Test Results

Video Head Impulse Test Classification	Description
Normal	Mean gain values between 0.8 and 1.2 for the lateral SCCs. Mean gain values between 0.7 and 1.2 for the anterior and posterior SCCs AND No pathological saccades.
Pathological saccades	Appear in more than 50% of head impulses. Minimum amplitude of at least half the velocity of the head movement. Saccades must appear in the opposite direction of the head turn. Must occur approximately 100 ms after initiating head movement to approximately 100 ms after the end of head movement.
Inconclusive - Normal mean gain values AND pathological saccades - Low mean gain values WITHOUT pathological saccades	Normal mean gain value with pathological saccades. Mean gain values below normal without accompanying pathological saccades.
Pathological	Pathological saccades AND mean gain values below 0.8 for lateral and below 0.7 for anterior and posterior SCCs.

SCC, semicircular canal.

Consent to Participate and Ethical Approval

The study design and procedures have been approved by the North Denmark Region Committee on Health Research Ethics. Trial registration number and date of registration: 2020-033, April 2, 2020. Written informed consent was obtained from all participants included in the study.

Statistical Analysis

Microsoft Office 16 Excel was used to perform calculations. The data distribution was presented as mean, standard deviation (SD), median, 25th and 75th percentiles, minimum, and maximum.

RESULTS

Population characteristics are shown in Table 2. Based upon the self-reported and medical journal of the population's level of consciousness, the population was divided into groups according to McCaslin (see Table 2).

The BPPV subtype and location are presented in Table 3.

The 5 patients required a total of 10 treatments resulting in a mean of 2 treatments per patient. Please note that subject 2 was lost to follow-up.

Of the included 85 patients, 10 (11.9%) could not cooperate with the vHIT examination and 1 (1.2%) was excluded because of previous meningitis. For a normal and pathological vHIT example, see Figure 4.

Table 2. Population Characteristics

Characteristics	Value	Minimum	25th percentile	Median	75th percentile	Maximum
Patients, n	85					
Age (years), mean (±SD)	43.46 (17.19)	18.62	26.02	46.25	54.70	86.84
Sex, n (%)						
Male	40 (47.1)					
Female	45 (52.9)					
Time from head trauma to examination (days), mean (±SD)	26.78 (14.37)	6	19	23	33	96
GCS observed in the ED, n (%)						
GCS 15	75 (88.2)					
GCS 14	8 (9.4)					
GCS 13	1 (1.2)					
GCS 9	1 (1.2)					
Minimal head trauma	55 (64.7)					
Mild head trauma	28 (32.9)					
Moderate head trauma	2 (2.4)					
Patients with BPPV, n (%)	6 (7)					

SD, standard deviation; GCS, Glasgow Coma Scale; ED, emergency department; BPPV, benign paroxysmal positional vertigo.

The distribution between the 3 groups is depicted in Table 4 and the hypofunctioning SCCs are shown in Table 5.

Furthermore, 3 patients with pathological vHIT also had an inconclusive low mean gain—no saccades, all in the right anterior SCC and 2 of them had another in the left lateral or right posterior SCC. Of the 56 patients with inconclusive low mean gain with no concomitant saccades, 21 patients had affection of a single SCC, 25 had affection in 2 SCCs, 9 had affection in 3 SCCs, and 1 had affection of 4 SCCs. For DHI scores, see Table 6.

DISCUSSION

Benign Paroxysmal Positional Vertigo

Overall, these results indicate an incidence of BPPV of 7% which is comparable with the results of Naguib et al.[21] Józefowicz-Korczyńska et al.[22] and Motin et al[23] at 4.8%, 5%, and 6.6% respectively. In contrast, other studies have found higher incidence rates ranging from 14.6% to 28%.[24-26] Packer et al[24] included mostly severe or extremely severe brain injuries and that might explain why they found a higher incidence. On the other hand, Motin et al[23] also described a population with severe traumatic brain injury and they found a lower incidence of BPPV of 6.6%. When comparing another population, who suffered mild head trauma, Hoffer et al[26] found an incidence of 28%. However, their population consisted of patients who all complained of dizziness, whereas this study population included both patients with and without complaints of dizziness following minor head trauma. Since vertigo/dizziness is a prerequisite for the diagnosis of BPPV, a higher incidence of BPPV among patients with dizziness is to be expected. The population of Józefowicz-Korczyńska et al[22] also consisted of patients with mild head trauma, but their incidence was much lower at 5% even though their population also complained of dizziness or postural instability. Haripriya et al[25] also reported a high incidence of BPPV although their population distribution between mild and moderate head injuries was more comparable to this study population. However they included more specific types of traumas, and this study only included patients diagnosed with a cerebral concussion. Haripriya et al[25] included both motor vehicle accidents and whiplash injuries, which could be the reason they found higher incidence of BPPV.

Table 3. Benign Paroxysmal Positional Vertigo Characteristics

Subject and Location	Subtype
Subject 1	
Right posterior SCC	CAN
Right lateral SCC	CUP
Subject 2	
Right anterior SCC	CAN
Subject 3	
Right posterior SCC	CUP
Left posterior SCC	CUP
Left lateral SCC	CAN
Subject 4	
Right posterior SCC	CAN
Subject 5	
Left posterior	CAN
Subject 6	
Right Posterior	CAN
Left Posterior	CAN

SCC, semicircular canal; CAN, canalolithiasis; CUP, cupulolithiasis.

Only Packer and Józefowicz-Korczyńska et al[22] had the same diagnostic criteria for BPPV as this study and examined all 3 paired SCCs. Motin et al[23] and Naguib et al[21] used the DH test with concomitant nystagmus and vertigo as diagnostic criteria but did not mention the horizontal plane or any BPPV subcategories. Haripriya et al[25] used both the SRT and DH tests with accompanying nystagmus but did mention anything about neither anterior SCCs nor vertigo during the tests. Lastly, Hoffer et al[26] used only the DH test or the modified DH test together with a history of positional vertigo as diagnostic criteria but did not mention anything about vertigo during the tests.

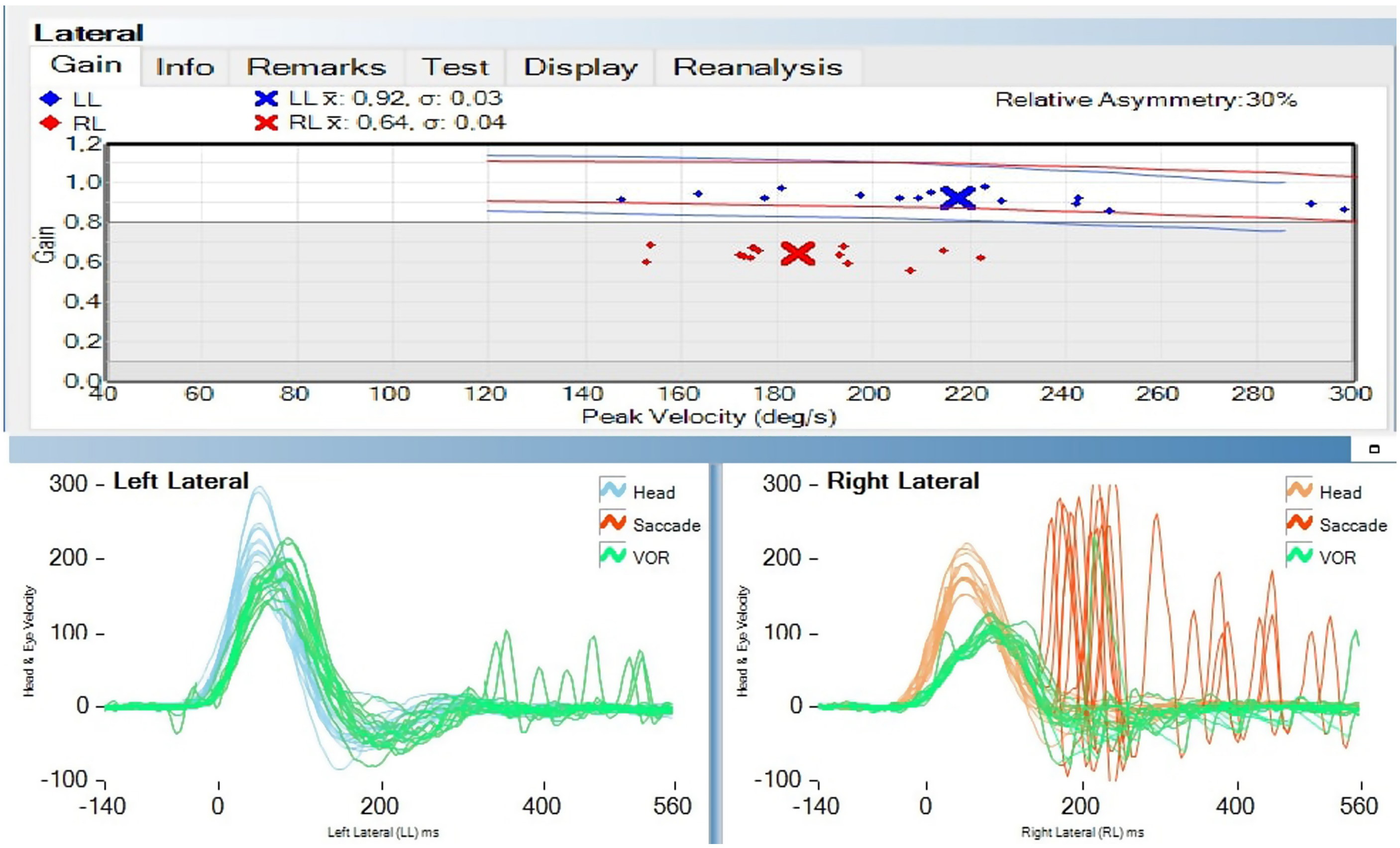

Figure 4. Video head impulse test results of a normal left lateral semicircular canal (SCC) and a pathological right lateral SCC. The upper figure shows the gain values accompanying the peak head velocities of the individual head impulses applied. X-axis: peak head velocity (degrees/second), y-axis: gain values. White area shows the normal range of gain values, and the grey area shows the pathological range of gain values. Red: right lateral SCC, blue: left lateral SCC. Red cross shows the right mean gain value, and blue cross shows the left mean gain value. Solid red line indicates the range of age-specific normal gain values for the right lateral SCC, and solid blue line indicates the range of age-specific normal gain values for the left SCC. The numeric mean gain value is listed at the top with red indicating the right lateral SCC mean value (0.64) and blue indicating the left mean SCC value (0.92). The lower figure shows a graphical presentation of left and right lateral SCC head impulses. X-axis: time (milliseconds), y-axis: peak head and eye velocities (mirrored view). Green curve shows the vestibular ocular reflex (VOR) eye movement, blue curve shows the left head impulses, orange curve shows the right head impulses, red indicates pathological saccades if predefined criteria are met with the accompanying software. Please note that the head and eye velocity curves follow the same pattern (normal examination) curves with testing of the left lateral SCC and note that the head and eye velocity curves do not match (indicating a low gain value) and that pathological saccades are present with right lateral SCC testing immediately after the head turn stops (overt saccades).

All these differences in diagnostic criteria make direct comparison of the studies troublesome.

Besides the heterogenous diagnostic criteria for BPPV, the classification of the severity of the triggering trauma also differed. Packer used the length of post-traumatic amnesia to define the severity of the head trauma and mainly examined severe and extremely severe head trauma patients. Motin et al[23] claimed to examine patients with severe traumatic brain injury, but they did not define a severe traumatic brain injury. Hoffer et al[26] and Haripriya et al[25] examined respectively mild and mild to moderate head traumas using Glasgow Coma Scale (GCS) for their classification. Naguib et al[21] examined a broad variation from mild to severe head traumas. One could hypothesize that the more severe the head trauma is, the more likely the patient is to develop BPPV. However, because of the discrepancy among the reported BPPV incidences of BPPV following head trauma, neither does it not appear to be so straightforward to make this conclusion nor is it possible to confirm or deny this statement based on the currently available literature.

Table 4. Distribution of Video Head Impulse Test Results Following Post-Test Classification

Video Head Impulse Test	Amount (%)
Normal	15 (20.27)
Inconclusive	54 (72.97)
• Normal gain with pathological saccades	1 (1.35)
• Low gain with no pathological saccades	56 (75.67)
• Both	1 (1.35)
Pathological	5 (6.76)

Traumatic BPPV is more likely to affect multiple ipsilateral SCCs or bilateral SCCs when compared to idiopathic BPPV. Like previously mentioned studies, the results comparing traumatic BPPV to idiopathic BPPV display some interesting differences. Incidence of bilateral affection ranged from 3% to 32%[9,10,12,13,27,28] and multiple SCC affection ranged from 6.25% to 55%.[9,11,13,27] Three subjects (50%) in this study had BPPV in multiple SCCs.

An MRC provides predetermined and reproducible positions for both testing and treatment, thereby enabling a systematic, uniform

Table 5. Distribution of Video Head Impulse Test Results by Individual Semicircular Canal Vestibular Ocular Reflex Function. Please Note That Very Few Inconclusive Test Results Are Seen with Lateral SCC Testing

Semicircular Canals SCC(s)	Number (%)
Conclusive	340 (76.6)
Normal	334
Pathological	
• Right posterior	4
• Right lateral	1
• Left lateral	1
Inconclusive	104 (23.4)
Low mean gain value without pathological saccades	
• Right anterior	46
• Right posterior	38
• Left anterior	16
• Left posterior	2
• Left lateral	1
Normal mean gain value without pathological saccades	
• Right lateral	1

SCC, semicircular canal.

Table 6. Dizziness Handicap Inventory Questionnaire Scores of Entire Study Population

	Minimum	Median	Maximum
Dizziness handicap inventory			
Physical mean score	0	6	20
Emotional mean score	0	4	28
Functional mean score	0	4	32
Total mean score	0	16	84
Group distribution (n)			
No handicap	41		
Mild	15		
Moderate	17		
Severe	12		

standardized approach. The addition of VNG goggles allows more precise diagnostics due to improved eye monitoring with enhanced eye movement visualization, eye tracking, and velocity measures. However, misinterpretation is possible since all types of nystagmus are observed and measured even though not always clinically relevant. Compared to traditional diagnostics and treatment on an examination bed, the MRC requires less cooperation from the patient, because the entire body is moved instead of moving only the neck and upper body. In this way, patients with a stiff neck or patients who experience back problems may be diagnosed and treated quite unproblematically. However, examination and treatments with an MRC where vision is denied and the patient tied to the chair may seem claustrophobic to the patient. In contrast, performing the positional testing and treatment by traditional manual tests and maneuvers on an examination bed is quite simple, easy, and less time-consuming. Furthermore, this modality allows the examiner to bear a patient's personal need in mind, for example, back pain. Potential flaws with traditional diagnostics and treatments include: (1) high degree of patient cooperation, (2) inferior eye monitoring during diagnostics and treatment with no possibility of tracking nystagmus patterns during positioning tests and maneuvers, and (3) the positioning of the patient is more imprecise in terms of exact degrees of angels and rotations and, as a direct consequence hereof, a higher degree of inter- and intra-variability must be anticipated.

Video Head Impulse Test

Following completion of the study, the vHIT goggles were compared to another pair of identical goggles. This comparison suggested that there might have been some misleading gain values with the equipment used. Theoretically, this may have affected the results in a way that a higher number of "inconclusive" results were seen. Strict criteria were applied by Abrahamsen et al[19] in order to analyze and conclude the pathological examinations.[19]

Results would be very different if the criteria defining a pathological vHIT were changed. Other studies have defined a pathological vHIT by solely low mean gain values. If this definition was applied to this study, the results would be 58 (78.38 %) pathological vHITs and 16 (21.62%) normal vHITs. Contrarily, if a pathological vHIT was defined by solely pathological saccades, 6 (8.1%) would be pathological and 68 (91.9%) would be normal. An advantage of defining a pathological vHIT with only low mean gain values is that you rule out the interindividual variation in the interpretation of test results. On the other hand, individual assessments are used to discard any noise and/or artifacts that the accompanying software did not remove.[16] Contrarily, by defining a pathological vHIT only to pathological saccades with no regard to the mean gain values, the test solely depends on a subjective assessment; in addition, the test is technically demanding, requires a cooperative patient, and might be affected by several sources of error.[16,19]

A study by Alsheri et al[29] found no pathological vHIT in postconcussion patients overall. Their population consisted of both adolescents and adults, whereas this study only examines patients above 18 years. Furthermore, they only examined the lateral SCCs and their definition of a pathological vHIT was a gain value below 0.8. Despite these obvious differences in set-up and definition of a pathological vHIT test, the lateral SCC test results from this study are comparable. On the other hand, they describe some measurements with a mean gain value above 1.2. According to Hougaard et al.[16] the range of a normal VHIT for the lateral SCC is 0.8-1.2.

Alkathiry[30] also used vHIT to evaluate lateral SCC VOR function and compared adolescents with a sports-related concussion to a healthy control group and found no differences using only low mean gain values as a predictor of pathological vHIT. Despite both studies examining adolescents, they found no correlation between concussion and pathological vHIT. This is comparable to the findings in this study since no low mean gain values for lateral SCCs were found but only normal mean gain values for pathological saccades (in this study classified as inconclusive results).

Dizziness Handicap Inventory

This study's 5 participants who filled out both pre- and post-treatment DHI questionnaires had a difference in total scores, which categorized 4 out of 5 (80%) into the no handicap group and only 1

Table 7. Dizziness Handicap Inventory Scores of Patients Diagnosed with Benign Paroxysmal Positional Vertigo Before and After Treatment

	Subject 1	Subject 3	Subject 4	Subject 5	Subject 6
Before treatment					
Physical score	18	6	22	18	20
Emotional score	28	4	2	14	6
Functional score	28	4	10	28	18
Total score	74	14	34	60	44
After treatment					
Physical score	22	0	2	2	0
Emotional score	18	0	0	2	0
Functional score	22	0	0	2	0
Total score	62	0	2	6	0

patient in the group with a severe handicap post-treatment. In this case, one could speculate that additional damage might be present. One study by West et al[31] found that the mean DHI scores did not normalize following successful treatment, but in this case, decreased from 45 points prior to the first treatment to 22 points after the final treatment (Table 6 and Table 7).

Strengths of This Study

This study was carried out by a highly trained medical student with experience in using an MRC with VNG equipment. Moreover, the test and treatment set-up of this study made it possible to examine the patients in standardized test conditions and therefore made the results more reliable and less examiner-dependent.

The power calculation of this study is based upon the study of Motin et al[23] and Naguib et al[21] using the normal standard variate of 1.96 and an absolute error of 0.05. The total number of participants needed was 84. Since this study included data from 85 patients, the true incidence of BPPV within this group of patients was determined with high probability.

Limitations

The medical student did not have any previous experience with vHIT testing prior to this study. However, the student received thorough instructions and training by a skilled and very experienced senior neurotologist. The number of subjects with BPPV is quite low. Therefore, the recurrence rates of BPPV, since these results are preliminary, and relapses may occur much later than 2 months following treatment.

CONCLUSION

This study found an incidence of BPPV following head trauma of 7%. Benign paroxysmal positional vertigo was seen in all SCCs with the posterior SCC being the most common location. Fifty percent of the patients had multiple SCC affections. On average, the number of treatments required for complete resolution of BPPV was 2. Five patients (6.7 %) had a pathological vHIT and 54 (72.9 %) had an inconclusive vHIT examination. As secondary BPPV often includes atypical BPPV with bilateral BPPV and multi-SCC BPPV, diagnostic procedures with the most advanced eye tracking equipment and positioning maneuvers are recommended to minimize the number of overlooked, misdiagnosed, and, as a direct consequence hereof, not sufficiently treated BPPV.

Ethics Committee Approval: Ethical committee approval was received from the North Denmark Region Committee on Health Research Ethics (2020-033, April 2, 2020).

Informed Consent: Written informed consent was obtained from all participants who participated in this study.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept – J.K.J., D.D.H.; Design – J.K.J., D.D.H.; Supervision – D.D.H.; Materials – J.K.J., D.D.H.; Data Collection and/or Processing – J.K.J.; Analysis and/or Interpretation – J.K.J., D.D.H.; Literature Review – J.K.J., D.D.H.; Writing Manuscript – J.K.J., D.D.H.; Critical Review – J.K.J., D.D.H.

Declaration of Interests: The authors declare that they have no conflict of interest.

Funding: The authors declared that this study has received no financial support.

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