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VESTIBOLOGY

# Canal switch and re-entry phenomenon in benign paroxysmal positional vertigo: difference between immediate and delayed occurrence

## *Conversione canalare e fenomeno del rientro nella vertigine parossistica posizionale benigna: differenze tra forma immediata e ritardata*

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SUMMARY

This prospective study was designed to evaluate the differences between immediate and delayed canal re-entry of otoliths after therapeutic manoeuvres in patients with benign paroxysmal positional vertigo (BPPV). A total of 196 patients with BPPV were visited and 127 matched our inclusion criteria. The mean age was 54.74 years. The horizontal semicircular canal (HSC) was involved in 30 cases and the posterior semicircular canal (PSC) in 97 patients. Patients with hearing loss in the ear affected by BPPV have a more recurrent form, compared to those with normal hearing. An immediate canal re-entry was recorded in 3 patients with HSC BPPV, all with geotropic nystagmus. In 7 patients with PSC BPPV, the immediate canal re-entry was detected and the delayed form was noted in 5 patients. The patients with the delayed canal re-entry underwent more than 2 previous manoeuvres. The canal re-entry was not related to the manoeuvre performed. The timing of the Dix-Hallpike test to verify the resolution of the BPPV had a significant role in immediate canal re-entry. A recurrence in the follow-up at least one month after treatment was recorded in 20 patients and was more frequent in patients that had canal re-entry. The canal re-entry or canal switch is a clinical entity that should be kept in mind of the neurotologist when approaching BPPV patients. It is important to distinguish it from recurrence when delayed and from manoeuvre failure when immediate. The timing of manoeuvre performing, in particular the final verification test after therapeutic sessions, is important to prevent the immediate reflux of particles into canals.

KEY WORDS: Benign paroxysmal positional vertigo • Canal conversion • canal switch • Vertigo • Dizziness

RIASSUNTO

*Studio prospettico ideato per la valutazione delle differenze tra la conversione canalare o il rientro degli otoliti nei canali semicircolari successivo alle manovre terapeutiche nei pazienti affetti da VPPB. Sono stati valutati 196 pazienti affetti da VPPB, 127 dei quali corrispondevano ai criteri di inclusione. L'età media dei pazienti era di 54.74 anni. Il canale orizzontale è stato coinvolto in 30 casi e il canale posteriore in 97 pazienti. I pazienti con sordità neurosensoriale presentavano forme ricorrenti di VPPB, rispetto a quelli con udito normale. L'immediato rientro canalare è stato diagnosticato in 3 pazienti con VPPB del canale laterale, tutti con nistagmo geotropo. 7 pazienti con VPPB del canale posteriore hanno presentato un rientro canalare immediato e 5 la forma ritardata. I pazienti con rientro canalare ritardato avevano precedentemente subito più di 2 manovre di riposizionamento. Il rientro canalare non è risultato connesso al tipo di manovra eseguita. Il tempo di attesa tra l'esecuzione della manovra liberatoria e il test di verifica si è rivelato importante ai fini del rientro canalare immediato. La recidiva della BPPV dopo un mese dalle manovre liberatorie si è riscontrata in 20 pazienti ed è stata più frequente in quei pazienti che hanno avuto un fenomeno di rientro canalare. La conversione canalare ed il fenomeno del rientro canalare rappresentano delle entità cliniche che devono essere considerate dal medico che tratta le VPPB. Appare importante distinguere un rientro da un fallimento della manovra in caso di forme immediate, o da una recidiva di patologia in caso di forme ritardate. L'esecuzione del test di verifica del successo terapeutico dopo manovre di riposizionamento deve avere un distacco temporale sufficientemente ampio al fine di evitare il reflusso immediato di otoliti nei canali.*

PAROLE CHIAVE: *Vertigine parossistica posizionale benigna • Rientro canalare • Conversione canalare • Vppb • Manovre • Vertigini • Disequilibrio • Otologia • Neurotologia*

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## Introduction

Benign paroxysmal positional vertigo (BPPV) accounts for about 20% of vestibular complaint [1]. Being a mechanical disorder of the posterior labyrinth, management consists of a "mechanical" repositioning of the otoconial debris detached from vestibular sensorineural epithelia. The posterior semicircular canal (PSC) is the most involved by BPPV with approximately 90% of cases, while horizontal semicircular canal (HSC) is the next most common [2]. Both

canalithiasis and cupulolithiasis theories are accepted in the pathophysiology of the BPPV, which are also confirmed by intraoperative findings of otoconial debris into canal [3]. The repositioning manoeuvres to treat canalithiasis are well established and widely used, with some variation recently reported in literature [4-6].

The recurrence of BPPV may be linked to some systemic diseases [7-9], but true recurrence should be differentiated from true persistence of canalithiasis, which is often due to a reflux of otoliths.

Although repositioning manoeuvres are free of major complications, a form of canalithiasis called "re-entry BPPV" may appear after therapeutic manoeuvres [10]. This type of positional vertigo can also be called "canal switch BPPV" if the canal involved is different from the firstly affected canal [11] before any repositioning session. These clinical entities arise when manoeuvres became common in clinical practice, hence the clinician should consider a quick differential diagnosis to distinguish a re-entry form from recurrent BPPV by an early verifying test.

In our practice, we have noted two forms of canal re-entry and/or canal switch. The first is immediate, occurring some minutes after the repositioning session. The second is delayed, occurring after one or two days after the manoeuvres were done.

In our present work, we report the differences between the two clinical forms of canal re-entry and provide some suggestions to avoid phenomenon supported by clinical evidence.

## Materials and methods

The study was conducted prospectively in the period from January to July 2013. The setting of the study was in an ENT and audiology departments in a referrals centre for diagnosis and management of equilibrium diseases. Patients affected by BPPV were consecutively included in the study and exclusion criteria were: atypical nystagmus [12 13], associated Meniere's disease, bilateral BPPV, multicanalar BPPV, secondary BPPV, recent whiplash injury [14], clinical suspect for cupulolithiasis, unable to undergo repositioning manoeuvre for physical limitations.

Diagnosis of canalithiasis BPPV was done with and without Frenzel lens to allow the fixation of a specific point (nose of the examiner) during the examination to reduce the variability of nystagmus description among patients, which may be influenced by gaze. The nystagmus was then described observing the movement of iris-pupil complex and the ocular globe. A torsional nystagmus beating toward the more dependent side (geotropic) in Dix-Hallpike position was considered as canalithiasis of ampullary arm of ipsilateral PSC; if the torsional nystagmus in the Dix-Hallpike position was beating towards the unexamined side (apogeotropic) it was considered as canalithiasis of non-ampullary arm of examined PSC according to the description of Vannucchi et al. [15] The superior semicircular canal (SSC) BPPV was examined in the head-hanging position, although the side is difficult to determine [6]. The HSC was examined with the roll-test eliciting the horizontal nystagmus, and considering the affected ear the side with more intense nystagmus in case of geotropic form, while the side with less intense nystagmus in case of apogeotropic form.

The manoeuvres to treat the canalithiasis BPPV were: Semont manoeuvre or Gans manoeuvre for PSC BPPV [4 16], Gufoni maneuverer for HSC [2]. The choice between the Semont and Gans manoeuvre was determined by randomising patients with PSC BPPV, undergoing one of the two manoeuvres. All treatments were performed at the same visit until the verifying Dix-Hallpike/Roll-test was without evidence of nystagmus or symptoms. During the manoeuvre, patients kept the position for 120 sec, and the following manoeuvre (when needed) was done after an additional 120 sec. To determine the influence of the time lapse between the repositioning manoeuvre and the final Dix-Hallpike/Roll-test, we randomly divided patients into 3 groups and the final test was done, respectively, after 5, 10 and 15 minutes after the repositioning manoeuvre. The minimum follow-up was 3 months after the manoeuvre.

Data were entered in a database created with Excel 5.0. Data analysis was performed using EpiInfo 3.5.1 software. Absolute and relative frequencies were calculated for qualitative variables, while quantitative variables were summarised as means (standard deviation). Differences by groups for categorical variables were analysed using the chi-square test. Differences in means were compared with a Student's t-test.

Univariate analysis between BBPV and possible factors associated was performed. The difference between the PSC and the HSC related to the different manoeuvres was analysed. A $p < 0.05$ (two-tailed) was considered statistically significant.

Institutional review board approval was obtained for this study without human experimental procedures. The choice of the manoeuvre used was done among manoeuvres with equal success rates, as often reported in the literature.

**Table I.** Hearing loss is statistically associated with recurrent BPPV.

| | Previous BPPV | | | p value |
|---|---|---|---|---|
| n = 127 | 0 | 1 | > 2 | |
| | | n (%) | | |
| **Tinnitus** | | | | |
| - Yes | 9 (45.0) | 3 (15.0) | 8 (40.0) | 0.22 |
| - No | 46 (43.0) | 34 (21.8) | 27 (25.2) | |
| **Hearing Loss** | | | | |
| - Yes | 6 (42.9) | 0 | 8 (57.1) | < 0.01 |
| - No | 49 (43.4) | 37 (32.7) | 27 (23.9) | |

**Table II.** Patients with delayed canal re-entry had more than two manoeuvres in the same session to treat BPPV.

| PSC (n = 97) | Canal Re-entry | | | | |
|---|---|---|---|---|---|
| | None | Immediate | Delayed | No | Yes |
| | | n (%) | | n (%) | |
| Number of manoeuvres in a single session | | | | | |
| - 1 | 62 (92.5) | 5 (7.5) | 0 (0.0) | 62 (92.5) | 5 (7.5) |
| - 2 | 18 (90.0) | 2 (10.0) | 0 (0.0) | 18 (90.0) | 2 (10.0) |
| - 3 | 5 (71.4) | 0 (0.0) | 2 (28.6) | 5 (71.4) | 2 (28.6) |
| - 4 | 0 (0.0) | 0 (0.0) | 1 (100.0) | 0 (0.0) | 1 (100.0) |
| - 5 | 0 (0.0) | 0 (0.0) | 2 (100.0) | 0 (0.0) | 2 (100.0) |

**Table III.** Influence on re-entry phenomenon of the timing to repeat the diagnostic manoeuvre after treatment.

| Minutes waited before last Dix-Hallpike test | Canal Re-entry | | | p-value | Canal Re-entry | | p value |
|---|---|---|---|---|---|---|---|
| | None | Delayed | Immediate | | No | Yes | |
| | | n (%) | | | n (%) | | |
| - 5 | 29 (70.7) | 2 (4.9) | 10 (24.4) | > 0.001 | 29 (70.7) | 12 (29.3) | > 0.001 |
| - 10 | 41 (95.3) | 2 (4.7) | 0 (0.0) | | 41 (95.3) | 2 (4.7) | |
| - 15 | 42 (97.7) | 1 (2.3) | 0 (0.0) | | 42 (97.7) | 1 (2.3) | |

## Results

In the period considered, we consecutively visited 196 patients with BPPV, of which 69 matched our exclusion criteria and were not included in the analysis. The sex distribution was 49 men and 78 women. The mean age was 54.74 years. In 55 patients, the episode of BPPV was the first, while 72 patients had had a previous BPPV episode more than 6 months before. The statistical analysis of relationship between recurrence and comorbidities or personal patients data did not demonstrate any significance.

The HSC was involved in 30 cases of which 5 presented an apogeotropic nystagmus. In 97 patients, PSC BPPV was diagnosed and 13 cases showed an apogeotropic nystagmus.

The patients with hearing loss in the ear affected by BPPV seemed to have a more recurrent form compared with those with normal hearing (Table I).

An immediate canal re-entry was recorded in 3 patients with HSC BPPV, which was promptly managed with a Gufoni manoeuvre. These patients, having geotropic nystagmus before the manoeuvre, had the classical freeing nystagmus during the Gufoni manoeuvre, but geotropic nystagmus persisted at the verifying test. In patients with HSC BPPV, we recorded canal switch only for those cases with geotropic nystagmus, probably because the otolith mass lied near the vestibular opening of the PSC.

In patients with PSC BPPV, a canal re-entry was noted in 12 patients; 7 patients had an immediate canal re-entry (with changed nystagmus direction to apogeotropic form), and 5 patients the delayed form. As shown in Table II, the patients with the delayed canal re-entry underwent more than 2 manoeuvres in the same session to achieve the disappearance of the positional nystagmus. Although the result is quite evident, statistical significance was not obtained probably due to the low number of cases.

The canal re-entry was not related to the manoeuvre performed.

As shown in Table III, the timing of the Dix-Hallpike test to verify the resolution of the BPPV had a significant role in immediate canal re-entry, which occurred only for those patients who had a Dix-Hallpike after only 5 min from the last repositioning manoeuvre.

A recurrence in the follow-up at least one month after treatment was recorded in 20 patients and was more frequent in patients who had a canal re-entry ($p > 0.001$) (Table IV).

**Table IV.** Relationship between re-entry phenomenon and recurrence of BPPV.

| Recurrence | Canal Re-entry | | p value |
|---|---|---|---|
| | Yes | No | |
| | n (%) | | |
| - Yes | 11 (55.0) | 9 (45.0) | > 0.001 |
| - No | 4 (3.7) | 103 (96.3) | |

## Discussion

The treatment of BPPV is often simple and immediate, providing a prompt resolution of symptoms. On occasion, neurotologists encounter patients with resistant BPPV requiring several manoeuvres to obtain results, or patients who after an initial resolution of symptoms show some delayed positional nystagmus due to a canal re-entry of otoliths.

The immediate reflux of otolith into the PSC after a repositioning manoeuvre could be mistaken for a contralateral SSC BPPV, as these two forms of nystagmus are similar. As reported by Foster et al. [10], such a form of nystagmus should be differentiated because in PSC reflux it is finest due to inhibition of endolymphatic flow. However, as that discrimination is very difficult to detect, the clinician should consider that it is highly unlikely that a contralateral disease, previously undiagnosed, appears after a repositioning procedure.

The apogeotropic nystagmus in PSC during head-hanging position is due to otolith into the non-ampullary arm of PSC [15 17]. It could be possible that the apogeotropic nystagmus observed after retest could be caused by otolith mass stopping in the ampullary arm, although we observed in all cases a liberatory nystagmus after the first repositioning procedure. For this reason, we believe that the hypothesis of the otolith stopping in the ampullary arm is a less probably cause of apogeotropic nystagmus in this series.

Our clinical experience in detecting some canal conversion after reposition procedure was also recently reported by Babic et al. who described the transitional BPPV and, as in our present series, the conversion occurred after the final check to assess the freeing of the semicircular canal [18]. The large number of conversions in HSC cupulolithiasis is in our opinion not real, but influenced by the fact that the authors considered all apogeotropic nystagmus in HSC as cupulolithiasis, rather than contemplate the possibility of otolith in the ampullary arm of HSC, which is manageable with appropriate manoeuvre [2].

BPPV patients may have a variable otoliths mass, ranging from fine particles unable to elicit clinically-evident nystagmus [19] to high mass particles visible with the operating microscope [3]. The mass of otoliths, in our opinion, supported by the results obtained in this study, have a role in determining not only the difficulty to obtain particle repositioning, but also in the type of canal re-entry if present.

We agree with the theory that patients cleared with a single manoeuvre are likely to have some high mass or aggregated particles [10]. In patients with an immediate reflux episode, particles after the treatment procedure were probably located near the openings of the common crus and HSC, so that the re-entry was more simple in case of high mass particles rather than dispersed otoliths. This event was compatible with our findings, as our patients with immediate reflux underwent less than 2 manoeuvres to free the canal involved.

The majority of patients with BPPV requires a single manoeuvre to clean the canal. Patients requiring more than 3 repositioning manoeuvres to achieve cleaning of the canal (negative Dix-Hallpike control test) probably have a large number of low-mass otoliths that are dispersed into the utricle during the numerous manoeuvres performed. Effectively, in our series, patients with delayed re-entry/canal switch had more than 2 manoeuvres in the same session and a negative final Dix-Hallpike/Roll test. The canal re-entry or switch was evident after an average of 2-3 days; it is possible that this time lapse was necessary to assemble particles into the utricle before casual re-entry.

Undoubtedly, to distinguish delayed canal re-entry from recurrence can be difficult. The only consideration that leads us to believe that after 2-3 days a recurrence is effectively a re-entry phenomenon is the direction change of the nystagmus (i.e. a geotropic before the treatment becomes apogeotropic for PSC). For canal switch from PSC to LSC BPPV, the observation is different because it is very likely that a new episode of BPPV after a few days following treatment affecting a different canal of the same side is due to re-entry of otoliths.

Similar to Foster et al., we noted a relationship between timing of final test with canal re-entry [10]. These findings lead to couple the cause of re-entry BPPV or canal switch with the repetition of Dix-Hallpike test to assess cleaning of the canal. In our series, there was evidence that the minimum time that we should wait before doing a verification test, to reduce the risk of immediate re-entry/canal switch, was 10 min. Delayed canal re-entry is not preventable by increasing the time before performing the verification test, but it likely depends on a casual position/movements done by patients.

## Conclusions

Canal re-entry or canal switch is a clinical entity that should be kept in mind by the neurotologist when approaching BPPV patients. It is important to distinguish it from recurrence when delayed and from manoeuvre failure when immediate. It is likely that the mass of otoliths has a role in determining the type of canal re-entry. The timing of performing manoeuvres, in particular the final verification test after therapeutic sessions, is important to prevent the immediate reflux of particles into canals.

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