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Original Article

Evaluation of efficacies and recurrence rates of three self-treatment maneuvers for posterior semicircular canal benign paroxysmal positional vertigo

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Abstract: This study aims to compare the efficacies and recurrence rates following three self-treatment maneuvers, namely, the modified Epley maneuver (MEM), the modified Semont maneuver (MSM), and Brandt-Daroff maneuver (BDM), applied for posterior semicircular canal benign paroxysmal positional vertigo (PC-BPPV). One hundred sixty-eight patients were randomly divided into three groups treated with MEM (group 1:45 patients), MSM (group 2:43 patients), BDM (group 3:40 patients) respectively, and a fourth control (group 4:40 patients). Treatment efficacies for the four groups when treated for one week and for one month, as well as the recurrence rates after six months and the time needed for healing, were compared. The recovery rate of group 1 after one week (86.7%) was better than the rates of groups 2, 3, and 4 (53.5%, 35%, 15%, respectively) (χ^2=49.092, *P*=0.000), and the recovery rate of group 1 (95.6%) after a month was only better than group 3, but not the other groups (70%) (χ^2=8.42, *P*<0.05). Kaplan-Meier survival curves showed that recovery time for group 1 was shorter than those for the other three groups ($\chi^2_{1,2}$=10.850, *P*=0.001; $\chi^2_{1,3}$=25.779, *P*=0.000; $\chi^2_{1,4}$=35.085, *P*=0.000). There was no significant difference in the recurrence rates among the four groups after six months (χ^2=4.076, *P*=0.253). Logistic regression analysis showed that age and duration of disease before self-treatment were independent predictors of recurrence. MEM was more effective than MSM and BDM for patients with recurrence, but it could not reduce the recurrence rate.

Keywords: Positional vertigo, physical therapy

Introduction

Benign paroxysmal positional vertigo (BPPV) is the paroxysmal transient vertigo caused by specific changes in head position, accounting for 60% of peripheral vertigo, with an incidence rate of approximately 64/10000 [1, 2]. The peak of incidence occurs between 50 and 70 years of age, and the incidence rate in female is twice than that of males [1-4]. Of the types of BPPV, posterior semicircular canal BPPV (PC-BPPV) is the most common form, accounting for 85 to 90% of cases [2-5]. PC-BPPV was initially described by Barany, then by Dix and Hallpike in greater detail; furthermore, the Dix-Hallpike test induced paroxysmal rotary nystagmus [2]. In 1985, HC-BPPV characterized by horizontal downward nystagmus was named. In 1995, another new HC-BPPV was found, which is marked by longer horizontal upward nystagmus, and AC-BPPV manifested as downward rotary nystagmus in the Dix-Hallpike test was identified [2-4].

$CaCO_3$ crystals (otoliths) originating from the utricle often form the basis for BPPV [6], and canalith repositioning (CRP) is the most common method of treatment [7-9]. In 1980, based on otolithiasis at the ridge crest, Brandt and Daroff [10] were the first to propose the family self-practice method. They found that repeated movements of the head and torso from the seated position to ambilateral sides could alleviate the symptoms of 98% of PC-BPPV patients in 2 weeks by loosening the otoliths at the cupula. Since the late 1980s and early 1990s, the Semont maneuver and Epley maneuver have become the most commonly used CRP methods used for PC-BPPV; these maneuvers employ step-by-step head position transforma-

tions to return fallen-off otoliths from the semicircular canal back to the utricle, thus obtaining clearance. However, some patients could not achieve complete remission with a single treatment [2, 3, 7, 11]. In recent years, Radtke *et al.* [12, 13] modified the Epley maneuver and the Semont maneuver on the basis of CRP, so as to facilitate the patients' mastery of the maneuvers. This allowed for treatment at home, which was suitable for the patients who could not be relieved by a single treatment or who had repeated onsets. This study was designed to compare the clinical efficacies, adverse reactions, and recurrence rates of three self-treatment maneuvers, namely, the modified Epley maneuver, modified Semont maneuver, and traditional Brandt-Daroff maneuver.

Methods

Subjects

One hundred sixty-eight PC-BPPV patients were diagnosed in our hospital from January of 2009 to February of 2011, using the following diagnostic criteria: 1) a history of transient vertigo induced by the changes in head position; 2) vertigo incubation period of 3~5 s for a duration of <60 s, exhibiting the characteristic of "fatigue"; 3) characteristic tests: positive in Dix-Hallpike test and the rotary/downward vertical nystagmus pointed at the affected ear (geotropism), and negative in the supine head position test. The exclusion criteria were: 1) >70 years of age; 2) received other physical therapy(s) in the acute phase; 3) had bilateral BPPV or horizontal semicircular canal BPPV; 4) could not complete the physical therapy because of poor language comprehension or poor compliance; 5) had severe cervical disease, arrhythmia, heart failure, movement disorders, and upper gastrointestinal bleeding, etc. This study was conducted in accordance with the declaration of Helsinki. This study was conducted with approval from the Ethics Committee of Shaoxing People's Hospital. Written informed consent was obtained from all participants.

Grouping and treatments

Patients were randomly divided into four groups: group 1, in which modified Epley maneuver was performed, had 45 patients, group 2 had 43 patients executing the modified Semont maneuver, group 3 had forty patients who performed the Brandt-Daroff maneuver, and group 4 was the control group with forty patients who did not perform any maneuvers. Each group was administered 6 mg of betahistine mesylate tablets (Tid, trade name: Minshilang) as the baseline treatment. This study was conducted in accordance with the Declaration of Helsinki and with the approval of the Ethics Committee of Zhejiang University. Written informed consent was obtained from all participants.

Groups 1-3 were given graphical guidance of appropriate maneuvers to direct the movement sequences of the head and torso. The first operation was learnt and completed with the guidance of a doctor's demonstration, during which the doctor was instructed to correct mistakes and to specify the requirements. Patients were instructed to perform the maneuver thrice a day until the positional vertigo disappeared for 24 h; the maneuver could be ended when the clinical review indicated negative results on the Dix-Hallpike test. In addition, patients were instructed to record instances of dizziness, nausea, vomiting, and palpitation that occurred with each practice in the registration form. Group 4 was only instructed to record the time at which positional vertigo disappeared.

Each maneuver was performed as follows:

Modified Epley maneuver [12]: 1) The patient was seated on the bed, with the head rotated 45° towards the affected side, and a pillow was placed behind the shoulders for padding during subsequent supination, 2) The patient quickly lay down, with the pillow padding the shoulders and extending the neck, while the affected ear was oriented downwards; the patient maintained this position for at least 30 s or until the nystagmus disappeared, 3) The patient rotated his or her head 90° towards the contralateral side (without raising the head or rotating the torso), and maintained this position for at least 30 s, 4) the patient tumbled and rotated the head and torso together towards the contralateral side for continuous 90°, so that the patient could lie on his or her side on the bed (equivalent to head deviating from the supine position for 135°), and maintained this position for 30 s; 5) The patient maintained this head position and slowly sat up, while turning the head positively and forward for 20°.

Table 1. 4 Comparison of baseline data among the 4 groups

	Group 1 (n=45)	Group 2 (n=43)	Group 3 (n=40)	Group 4 (n=40)	F/χ^2	P
Age (years)	51.38±10.66	49.79±13.30	52.60±13.94	54±12.13	0.848[a]	0.469
gender (M/F)	15/30	14/29	15/25	17/23	1.121	0.772
affected side (right/left)	28/17	23/20	22/18	26/14	1.592	0.661
Idiopathic/secondary	39/6	33/10	35/5	34/6	2.308	0.511
First-time onset/multiple onset	37/8	39/4	37/3	35/5	2.348[Δ]	0.520
Average onset duration (days)	4.76±2.79	6.49±3.67	6.15±3.86	5.45±3.62	2.107[a]	0.101

NOTE: [a]: F value, and the rests were χ^2 value. [Δ]: Fisher exact test.

Modified Semont maneuver [13]: 1) The patient was seated at the edge of the bed, with his or her head deviating 45° towards the healthy ear, 2) The patient then quickly turned to the ipsilateral side, with the posterior side of the affected ear contacting the bed, maintained this position for 30 s, 3) The patient held a lateral head position, bodily moved head and torso, quickly sat up and reached the lateral position through the initial position, with the forehead of the healthy side touching the bed for 30 s, 4) The patient sat up and returned to the initial position.

Brandt-Daroff maneuver [10]: 1) The patient was seated at the edge of the bed, 2) The patient quickly turned to the affected side, with the ipsilateral occiput in contact with the bed, and this position was maintained for 30 s, 3) The patient sat up and returned to the initial position, and this position was maintained for 30 s; 4) The patient finally lay down in the lateral position.

Efficacy evaluation and follow-up

The treatment efficacies across the four groups after one week and one month of treatment, as well as the incidence rates of adverse reactions, recurrence rates after six months and the time needed for healing, were compared. The efficacy evaluation criteria were as follows: level I: cured; level II~III: effective; level IV: invalid. Efficacy criteria were as follows: level I: positional vertigo disappeared, Dix-Hallpike test (-); level II: no positional vertigo, with dizziness, sense of imbalance, Dix-Hallpike test (+) or (-); level III: symptoms of positional vertigo improved; Dix-Hallpike test (+); level IV: treatment was ineffective or the symptoms were aggravated. Adverse reactions: dizziness, nausea, vomiting, and palpitation.

All patient outcomes were followed up in clinics (regardless of whether the maneuver was completed or not) one week and one month after treatment to evaluate the efficacies and adverse reactions. During clinical review, each patient was asked to repeat the maneuver to confirm that the maneuver had been performed correctly. After six months of treatment, a follow-up telephone call was performed to inquire about the recurrence of symptoms. Positioning tests were performed on the patients reporting symptom recurrence to confirm the recurrence.

Statistical analysis

The SPSS 17.0 statistical package was used for analysis. Measurement data were expressed as $\bar{x}\pm s$, and Levene's test for equal variance was used. ANOVA was used to perform between-group comparisons, and the SNK-q test was used to perform paired intergroup comparisons. Count data were compared using the chi-square test or the Fisher's exact test. The efficacy evaluation used level information, and comparisons were performed using the Kruskal-Wallis H test for multiple independent samples. Intergroup comparisons were performed using the Nemenyi test. The recovery times were compared using the log-rank test of Kaplan-Meier survival curves.

Unconditional logistic regression analysis was performed to analyze the risk factors of recurrence, with $P<0.05$ considered statistically significant.

Results

Baseline data

The comparisons of baseline data among the 4 groups revealed no significant difference in

Table 2. Efficacy comparison of the 4 groups at Week 1 and Month 1

	Group 1 (n=45)		Group 2 (n=43)		Group 3 (n=40)		Group 4 (n=40)	
	Week 1	Month 1	Week 1	Month 1	Week 1	Month 1	Week 1	Month 1
I	39	43	23	32	14	28	6	29
II	4	1	8	6	8	6	10	8
III	2	1	10	5	12	6	15	3
IV	0	0	2	0	6	0	9	0

NOTE: pairwise comparison used Nemenyi test.

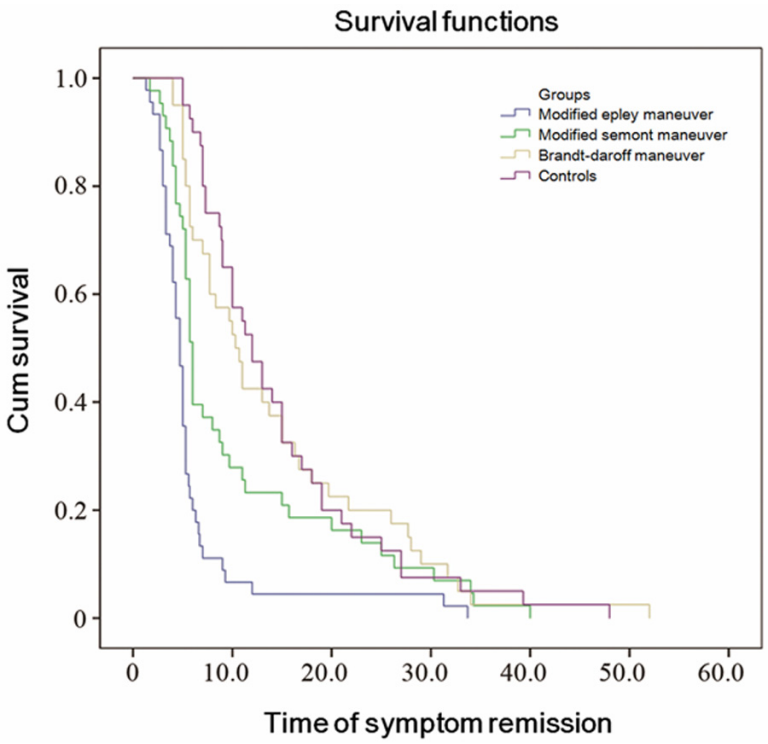

Figure 1. Comparison of Kaplan-Meier survival curves for time needed for BPPV healing. The log-rank test analysis revealed that the recovery time in group 1 was shorter than the other three groups ($\chi^2_{1,2}$=10.850, *P*=0.001; $\chi^2_{1,3}$=25.779, *P*=0.000; $\chi^2_{1,4}$=35.085, *P*=0.000). Recovery time was significantly shorter in group 2 than group 4 ($\chi^2_{2,4}$=4.689, *P*=0.030).

age, gender, affected side, cause of disease, onset times, and average onset duration (**Table 1**).

Efficacy comparison

Recovery rates at week 1 significantly differed between groups (χ^2=49.092, *P*=0.000) (**Table 2**). The paired intergroup comparison showed that the efficacy in group 1 was better than that in the other groups ($\chi^2_{1,2}$=8.55, *P*<0.05; $\chi^2_{1,3}$=23.23, *P*<0.01; $\chi^2_{1,4}$=44.00, *P*<0.01), while no significant difference was revealed when comparing groups 2 and 3 ($\chi^2_{2,3}$=3.75, *P*>0.05). Treatment efficacy in group 2 was significantly better than that in group 4 ($\chi^2_{2,4}$=14.49, *P*<0.01), while there was no significant difference between the efficacies of group 3 and 4 ($\chi^2_{3,4}$=3.35, *P*>0.05).

Recovery rates at month 1 differed significantly across experimental groups (χ^2= 10.529, *P*=0.015) (**Table 2**). The paired intergroup comparison showed that the efficacy in group 1 was better than that in group 3 ($\chi^2_{1,3}$= 8.42, *P*<0.05), while no significant difference was found when comparing groups 1, 2, and 4 ($\chi^2_{1,2}$=5.87, *P*>0.05; $\chi^2_{1,4}$=6.09, *P*>0.05). Comparisons between groups 2, 3, and 4 revealed no significant difference ($\chi^2_{2,3}$=0.27, *P*>0.05; $\chi^2_{2,4}$=0.01, *P*>0.05), and there was no significant difference between group 3 and 4 ($\chi^2_{3,4}$=0.18, *P*>0.05).

The recovery times of the four groups were compared by Kaplan-Meier survival curves, and the log-rank test analysis revealed that the recovery time in group 1 was shorter than the recovery times of the other three groups ($\chi^2_{1,2}$=10.850, *P*=0.001; $\chi^2_{1,3}$=25.779, *P*=0.000; $\chi^2_{1,4}$= 35.085, *P*=0.000). Recovery time was also significantly shorter in group 2 than in group 4 ($\chi^2_{2,4}$=4.689, *P*=0.030) (**Figure 1**).

Comparison of the adverse reactions

The incidence rates of adverse reactions such as vertigo, nausea, vomiting, and palpitation did not differ between the three repositioning groups (**Table 3**).

Comparison of the recurrence rates

There was no significant difference in recurrence rates between the four experimental

Table 3. Comparison of the incidence rates of adverse reactions among the 4 groups

	Group 1 (n=45)	Group 2 (n=43)	Group 3 (n=40)	χ^2	P
Vertigo	32/45	27/43	30/40	1.540	0.463
Nausea	19/45	16/43	22/40	2.805	0.246
Vomiting	13/45	10/43	10/40	0.383	0.826
Palpitation	7/45	5/43	8/40	1.102	0.576

Table 4. Comparison of the recurrence rates of the 4 groups at Month 6

	Group 1 (n=45)	Group 2 (n=43)	Group 3 (n=40)	Group 4 (n=40)	χ^2	P
Number of recurrence	6	9	12	11	4.076	0.253

Table 5. Logistic regression analysis of the risk factors of BPPV recurrence

	B	SE	Wald	OR	95% CI	P
Treatment maneuver	-0.129	0.214	0.363	0.879	0.578-1.336	0.547
Age (continuous)	-0.127	0.031	17.341	0.881	0.829-0.935	0.000*
Male	0.11	0.506	0.001	1.011	0.375-2.727	0.982
Onset time (days)	-0.282	0.075	14.318	0.754	0.651-0.873	0.000*
Left	0.573	0.487	1.386	1.774	0.683-4.609	0.239
Disease cause	0.193	0.619	0.097	1.213	0.361-4.078	0.755
One onset	1.326	0.840	2.491	3.765	0.726-19.538	0.115

NOTE: *: P<0.05 considered statistically significant.

groups at month 6 of treatment (**Table 4**). Unconditional logistic regression analysis showed that the risk factors of recurrence that were ultimately included in the model were only the age and onset time, while treatment maneuver, gender, affected side, disease cause and onset times had no impact on recurrence (**Table 5**).

Discussion

Otoliths constitute the basis of BPPV incidence, and currently there exist two hypotheses regarding its pathophysiological mechanism. In 1969, Schuknecht [14] described the post-mortem biopsy results of the temporal bone in three BPPV patients, in which he found dense particles attached to the utricular side of the ampullary crest of the semicircular canal. Therefore, the theory of cupulolithiasis was proposed. It posits that utricle-originated degenerated otoliths adheres to the ampullary crest of the posterior semicircular canal after shedding, thus, increasing sensitivity to gravity variations. In 1979, Hall proposed the theory of canalithiasis, based on the fatigue induced by repetitive stimulation [6], positing that the degenerated otoliths did not adhere to the crest of the posterior semicircular canal, but rather were suspended inside the endolymph of semicircular canal. When the head is in the induction position, the movements of otoliths within the endolymph, give rise to hydrodynamic traction leading to stimulation of the ampullary crest which induces symptoms.

CRP, which was designed based on the above theories, is the main method for treating BPPV. Among CRP methods, the Semont and Epley maneuvers are the most commonly used PC-BPPV repositioning strategies. These methods use step-by-step head position transformations to make the dislodged otoliths return from the semicircular canal back to the utricle, thus obtaining clearance. Self-treatment is a technical improvement based on CRP, aiming to equip patients with the necessary skills to perform the treatment themselves; it is therefore suitable for patients who do not experience relief after a single treatment or those with frequent recurrence [12, 13]. In this study, the clinical efficacies, adverse reactions, and recurrence rates following treatment with the modified Epley maneuver, modified Semont maneuver, and the traditional Brandt-Daroff maneuver were comparatively studied.

The recovery rate of modified Epley maneuver at Week 1 was 86.7% (39/45), which was higher than that of the modified Semont maneuver (53.5%, 23/43), the Brandt-Daroff maneuver (35%, 14/40), and the control group (15%, 6/40). The recovery rate following treatment with the modified Semont maneuver was significantly better than that of the control group, whereas the comparison between the modified

Semont maneuver and Brandt-Daroff maneuver, as well as between the Brandt-Daroff maneuver and the control group, revealed no significant differences. After one month of treatment, the recovery rate of the modified Epley maneuver was 95.6% (43/45), 74.4% for the modified Semont maneuver (32/43), 70% for the Brandt-Daroff maneuver (28/40), and 72.5% for the control group (29/40). The efficacy of only the modified Epley maneuver was better than the efficacy of the Brandt-Daroff maneuver, while the paired intergroup comparisons between other groups showed no significant differences. Kaplan-Meier survival curves were used to compare the recovery times for the four groups, and the log-rank test analysis revealed that the recovery time of the modified Epley maneuver was shorter than that of the other three groups. In this study, the efficacy of the modified Epley maneuver was similar to the efficacy of multiple treatments with the traditional Epley maneuver: the latter exhibited that the recovery rate following a single treatment was 70%, while the recovery rate following multiple treatments was nearly 100% [7]. The efficacy of the modified Semont maneuver was lower than the efficacy reported after multiple treatments with the traditional Semont maneuver, which could reach 90%-95% [7]. The efficacies of the Brandt-Daroff maneuver after one week of treatment was poor, consistent with the literature [12]. The treatment efficacies for the four experimental groups after one month were all greater than 70%, and this was considered to be due to repeated treatments. We were unable to exclude the possibility of some patients experiencing spontaneous remission. The incidence rates of adverse reactions, such as vertigo, nausea, vomiting, and palpitations, did not differ between the three repositioning groups. None of the patients experienced malignant adverse events, consistent with the literature [12, 13].

The observed differences in the efficacies of the three treatments are likely due to differences in the mechanisms that underlie each. The step-by-step forms of the modified Epley maneuver when otoliths passed through posterior semicircular canal were stable. The posterior semi-circular canal plane provided sufficient rotation of the head to ensure that the otoliths would be removed from of the semicircular canal. Therefore, even though the angular transformation had small operating deviations in case of the modified Epley maneuver, the impact of those on the treatment outcome would not be large [12, 13]. In contrast, small deviations in the implementation of the modified Semont maneuver and/or Brandt-Daroff maneuver may have large effects on treatment outcomes. The main factor involved in successful implementation of the modified Semont maneuver is the speed of head and torso's movements. When the patient is supine on the affected side, the otoliths may deposit in the lowest point, whereas when the patient quickly moves to the opposite side, the otoliths do not immediately fall into the end of the crista ampullaris of the semicircular canal due to inertia but may exit from the open end of upper apex. If the movements are not fast enough, the otoliths may fall back to the ampullaris instead of passing through the apex. The Brandt-Daroff maneuver may be limited in efficacy because it includes a pause in motion at the sitting position, making it more difficult for the otoliths to pass through the vertex. This compounded by the fact that its purpose was to promote the loosening and dissipation of otoliths [12, 13]. This study demonstrates that the modified Epley maneuver facilitates rapid relief of PC-BPPV symptoms to a greater degree than the modified Semont maneuver, the Brandt-Daroff maneuver, and drug treatment alone without any repositioning maneuvers.

After successful treatment with CRP, some PC-BPPV patients might relapse as recurrence rates of up to 44% within two years have been reported [15]. Helminski et al. [16] found that the traditional Brandt-Daroff maneuver could not reduce the recurrence rate of PC-BPPV. The author contends that this recurrence effect primarily reflects a recapitulation of the poor efficacy of the initial treatment: the recovery rate at week 1 was only 24%. However, the present study showed that even when using the highly effective modified Epley maneuver, daily practice could not reduce the recurrence rate, and the recurrence rates did not differ between the four treatment groups. Logistic regression analysis showed that age and disease duration before repositioning were independent predictors of recurrence, while repositioning method, gender, affected side, disease cause, and onset times were not related with the recurrence. Although Brandt et al. [17] reported that

the recurrence rates were highest in women and individuals with more than three onsets before treatment, we did not observe these phenomena. The 5-year follow-up study by Rashad and colleagues [18] indicated that average recurrence time for PC-BPPV was 46.3 months, while the recurrence time was longer in patients younger than 40 years of age, who had experienced symptom-durations of less than three years and fewer than six incidents. Gender did not correlate with the recurrence latency. Disease duration preceding recurrence was an independent predictor, and the recurrence rate in patients who had disease duration of greater than three years before treatment was 16.5 times that of those with a pretreatment duration of less than 3 years. This may be related to the fact that the patients with longer disease durations exhibited degenerative processes of otoliths, and these processes may lead to frequent or persistent shedding of otoliths.

The recurrence of BPPV may be associated with a variety of factors [18, 19], such as activation of a latent virus, blood vessels, immune, metabolic diseases, and long durations of confinement to bed, and would not be induced only by simple movements. Uneri and colleagues [19] found that in patients with idiopathic BPPV, the incidence of migraine was three times higher than in individuals with known BPPV causes. Vibert et al. [20] found that in female patients aged between 50 and 85 years of age, 75% of cases of BPPV were associated with osteoporosis.

In summary, the modified Epley maneuver has the capacity to rapidly relieve the symptoms of PC-BPPV to a greater degree than the modified Semont and Brandt-Daroff maneuvers. As such, it may be considered a first-line treatment in patients who exhibit vertigo recurrence. It should be noted that daily self-treatment could not reduce the recurrence rate or prevent the recurrence of BPPV. However, teaching patients to identify the affected semicircular canal and improve their self-treatment skills could improve their ability to control BPPV symptoms, as well as reduce the cost of the treatment.

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Disclosure of conflict of interest

None.

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