Treatment efficacy of various maneuvers for the lateral canal benign paroxysmal positional vertigo with apogeotropic nystagmus – a Randomized controlled trial

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Running title: LC-BPPV with apogeotropic nystagmus

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ABSTRACT

Objectives: To investigate the most effective treatment method by comparing the effects of various otolith reduction techniques in patients with apogeotropic lateral semicircular benign paroxysmal positional vertigo (LC-BPPV).

Methods: We performed a multicenter, randomized prospective study between January and December 2015 on 72 consecutive patients with apogeotropic LC-BPPV. The treatment group was divided into three groups: therapeutic head-shaking (THS, Group A), Gufoni-Appiani maneuver (Group B), and cupulolith repositioning maneuver (CuRM) (Group C). Each treatment group was evaluated and treated until the 4th week. “Treatment success” was defined as the disappearance of positional vertigo and nystagmus.

Results: This study included 72 patients (male: 49 and female: 23) with an average age of 55.4 ± 13.5 years (mean ± standard deviation [SD]). The mean duration of vertigo before treatment was 3.9 ± 4.4 d. The average latency and duration of nystagmus were 2.7 ± 3.0 and 47.9 ± 15.8 s, respectively. The total frequency of treatment was 2.0 ± 0.9. The number of treatments differed significantly among the three groups (p<0.05). After 4 weeks, the success rates for groups A, B, and C were 90.5%, 92.3%, and 100%, respectively. No significant difference was observed in the success rate between the treatment methods and period (p>0.05). However, the CuRM is the only method with a 100% treatment success rate.

Conclusion: There is no clear difference between the three treatments for LC-BPPV, but CuRM is relatively superior to the other treatments in the long term.

Keywords: LC-BPPV, cupulolith repositioning maneuver, Gufoni-Appiani maneuver, therapeutic head-shaking
INTRODUCTION

Benign paroxysmal positional vertigo (BPPV) is a condition wherein a particular position of the head stimulates the semicircular canal. Severe vertigo and recognizable nystagmus develop owing to the position of the otolith in the ampulla or semicircular canal.[1] According to reports, 18% of patients visiting dizziness clinics have BPPV, with a lifetime prevalence of 2.4% and a 1-year prevalence of 0.6%.[2]

According to the affected semicircular canal, BPPV can be divided into posterior semicircular canal BPPV (PC-BPPV), lateral semicircular-BPPV (LC-BPPV), and superior semicircular canal BPPV (SC-BPPV). PC-BPPV was the most common (80–90%), followed by LC-BPPV (10–20%) and SC-BPPV (~5%).[3] LC-BPPV is characterized by severe rotational vertigo and nystagmus when turning the head or body while lying down because of the anatomical orientation of the lateral semicircular canal.[4]

LC-BPPV is diagnosed based on characteristic nystagmus using the supine roll test (SRT), in which the head is turned to the left and right in the supine position. Positional vertigo and direction-changing horizontal nystagmus are the main symptoms of BPPV that affect the lateral semicircular canal.[5] Depending on the direction of the nystagmus with SRT, it can be divided into two types: geotropic and apogeotropic nystagmus types. Geotropic nystagmus type (LC-geo) accounts for most cases of LC-BPPV. It occurs when otoliths are present in the posterior arm of the lateral semicircular canal and are successfully treated with otolith reduction techniques such as the canalolith repositioning maneuver or Gufoni maneuver. The otolith in
the anterior arm of the lateral semicircular canal or the otolith attached to the cupula (cupulolithiasis) is thought to be the cause of apogeotropic nystagmus type (LC-apo) of LC-BPPV.[4] Cupulolithiasis is further divided into two subtypes depending on whether the otolith is attached to the utricular side or canal side of the cupula, and it can be assumed that a total of 3 subtypes of LC-apo exist.[6-8]

The treatment principle of BPPV is to move the otolith into the utricle space. Since the location of the otolith is different for each of the three types of LC-apo, a different treatment method is required for moving the otolith to the utricular space.

1) If the otolith is located in the anterior arm of the semicircular canal, a maneuver that moves the otolith to the posterior arm and changing it to a geotropic type is first required. Afterwards, it can be treated with a maneuver for LC-geo.

2) In the case of the cupulolithiasis-canal side, a maneuver is first needed to detach the otolith from the cupula, and then move it to the posterior arm to use LC-geo therapy.

3) In the case of the cupulolithiasis-utricular side, it can be treated by detaching the otolith from the cupula and moving it into the utricular space.

Theoretically, as above, a treatment tailored to each subtype should be selected, but the problem is that there has been no diagnostic test that can determine the exact location of otoliths in the LC-apo. The treatment performance of LC-apo is considerably lower than that of LC-geo, and the main reason is considered to be non-specific treatment without knowing the exact location of the otolith.

Treatment methods for apo-LC-BPPV reported to date can be divided into two categories. First, considering the cupulolithiasis as the etiology, therapeutic head-shaking (THS) [9], the Gufoni-Appiani maneuver[10], forced prolonged position, and vibrator application were suggested.[11] In 2005, Appiani modified Gufoni’s maneuver to convert an apogeotropic to a geotropic LC-BPPV.[10] In a recently published study on the treatment of
LC-BPPV by Italian group, the treatment for the apogeotropic type was indicated as Gufoni-APIanni.[12] These maneuvers have focused on the detachment of otoliths from the cupula. The second technique aims to separate the otolith, allow it to enter the semicircular canal, and return it to the utricle. These techniques include the 360-degree canalith repositioning procedure (CRP) [13], cupulolith repositioning maneuver (CuRM) [14], and Modified Semont maneuver.[15]

In this study, we compared the treatment efficiencies of 1) THS; 2) the Gufoni-Appiani method, which corresponds to the first category; and 3) the cupulolith repositioning maneuver, which corresponds to the second category. Since CuRM theoretically complete both the dropping and repositioning the otolith particles by single treatment session, it can be expected that the treatment efficiency of CuRM would be higher than the other 2 maneuvers. This study aimed to identify the most effective treatment method by comparing the effects of various otolith reduction techniques in patients with apogeotropic LC-BPPV.

MATERIALS AND METHODS

Patients

This study was a multicenter, prospective, randomized controlled study in which 17 researchers from 15 institutions from the Otological Research Interests Group in Korea participated.

Between January and December 2015, 72 consecutive patients with apogeotropic LC-BPPV were recruited. The inclusion criteria were as follows: 1) history of vertigo associated with changes in head position, 2) horizontal apogeotropic nystagmus detected with Frenzel glasses or video goggles in SRT, 3) absence of spontaneous nystagmus, 4) vertigo associated with nystagmus, and 5) primary BPPV. The exclusion criteria were 1) neurologic diseases...
related to positional nystagmus or vertigo, 2) other accompanying inner ear disorders, 3) history of head trauma, 4) multi-canal involvement, and 5) previous treatment with the CRP.

The study protocol was reviewed and approved by the Institutional Review Boards of each institution of participants and followed the tenets of the Declaration of Helsinki. Informed consent was obtained from all the patients (CMC, IRB No. XC13EIMI0119O).

**Study design**

This was a prospective, randomized trial consisting of three treatment groups. Patients who met the inclusion criteria were included in the study, and primary treatment was performed according to a random assignment table. We divided the treatment groups into three groups: THS (Group A), the Gufoni-Appiani maneuver for apogeotropic nystagmus (Group B), and the cupulolith repositioning maneuver (CuRM) (Group C). Three patients in each group recovered during the course of treatment. There were no subjects with follow-up loss. (Fig 1). After each treatment, no specific postural restriction existed, and antihistamines, tranquilizers, and antiemetic drugs were not prescribed (Fig 2). We recorded the symptoms, the direction of nystagmus (geotropic/apogeotropic), latency, and duration of nystagmus for up to 60 seconds at each treatment. The total CRP number and treatment duration for successful treatment were also evaluated.

**Evaluation and Successful Treatment Results**

The SRT was performed 20 minutes after treatment. If the nystagmus and rotational vertigo disappear, it is considered a "treatment success." If the apogeotropic nystagmus persisted, the assigned treatment maneuver for each group was performed again, and the patient was followed up one week later. In the case of nystagmus conversion to the geotropic direction, the Barbecue maneuver for geotropic LC-BPPV was performed to the Group A and C. The Gufoni maneuver for geotropic LC-BPPV was performed to the Group B. After the second
treatment, weekly assessment and treatment were performed until last assessment at 4th week. Treatment was repeated until positional vertigo and nystagmus was not evoked by SRT. If apogeotropic nystagmus was still induced by SRT at 4 weeks, it was determined as treatment failure.

Diagnostic procedure

The clinician selects cases in which rotational vertigo is induced by head movement, and induced vertigo disappears within 1–2 min. Spontaneous nystagmus, Dix-Hallpike test (DHT), and SRT were performed while wearing Frenzel glasses to diagnose BPPV and identify the affected semicircular canals. The diagnostic procedure was performed prior to each treatment session as follows.

Spontaneous nystagmus was first observed. The patient was brought from a sitting to a supine position, and the presence or absence of lying-down nystagmus (LDN) was observed. If specific nystagmus is present, the direction of nystagmus is checked until it disappears. When the nystagmus disappeared, the patient’s head was turned 90 degrees to the right, and vertigo symptoms and nystagmus were checked. The clinician recorded the latency, duration, and geotropic/apogeotropic direction of nystagmus. When nystagmus disappeared, the head returned to its center. If the nystagmus does not disappear after a while, it waits up to 1 min and then turns to the center. If nystagmus disappeared with the head in the central position, the head was turned 90 degrees to the left and examined in the same manner.

The lesion side was diagnosed as follows: when apogeotropic nystagmus was present on SRT, the direction of nystagmus with LDN was considered to be the affected lesion, and when there was no LDN, the direction of weak nystagmus was considered to be the affected lesion.[16] If geotropic nystagmus appeared in the SRT, the opposite direction of the nystagmus in the LDN was on the affected side. If there was no LDN, the side with the strongest nystagmus
was determined to be the affected side.

Treatment procedure

Therapeutic head-shaking

To keep the lateral semicircular canal parallel to the plane of rotation, the patients lay down with their heads bent at 30 degrees.[9,17] The clinician held the patient's head and shook it at an angle of 30 degrees to the left and right at a rate of 2 Hz for 15 seconds. Following the procedure, the patient lay down for 2 min.

Gufoni-Appiani maneuver [10,12,18]

The patient is seated in the center of the treatment table. Next, the patient quickly lays on the side with the affected ear down. Maintain this position until the nystagmus disappears. Turn the patient's head 45 degrees upward quickly and hold in this position for 2 min. Slowly return to a sitting position.

Cupulolith repositioning maneuver (CuRM) [19,20]

In the supine position, the head was quickly turned 90 degrees toward the affected side. Place a vibrator (60 Hz) on the posterosuperior part of the affected ear for 30 s and maintain this position for 2 min. Quickly turn the head 90 degrees toward the normal side (upright position) and hold for 2 min. The head was quickly turned 90 degrees toward the normal side (position of the affected ear facing the ceiling), a vibrator (60 Hz) was placed on the posterosuperior part of the affected ear for 30 s, and this position was maintained for 2 min. Quickly turn the head 90 degrees toward the normal side (prone) and hold this position for 2 min. Sit slowly with the patient’s head slightly bowed.
Chi-squared and Kruskal-Wallis tests were used to compare the clinical characteristics of the patients allocated to each treatment group and to determine the therapeutic efficacy of the three groups. All statistical analyses were performed using SPSS (version 12.0; SPSS, Chicago, IL, USA), and statistical significance was set at $p<0.05$.

RESULTS

Patient characteristics

This study included 72 patients (male: 49 and female: 23) with an average age of 55.4 ± 13.5 years (mean ± standard deviation [SD]). The mean duration of vertigo before treatment was 3.9 ± 4.4 days. On the affected side, the right side was more prevalent at 1.8:1. The latency and duration of nystagmus were 2.7 ± 3.0 seconds and 47.9 ± 15.8 seconds, respectively.

Groups A, B, and C each had 22, 26, and 24 patients, respectively. No significant differences were observed in sex, age, affected side, vertigo duration, nystagmus latency, or nystagmus duration among the groups. The number of repositioning maneuver for successful treatment was 2.0 ± 0.9. Group C (1.7±0.7) showed significantly less number of treatment than that of group A (2.1±0.9) and B (2.3±0.9) ($p<0.05$) (Table 1).

Treatment success rate

Cumulative success rate was not significantly different among the 3 groups at any assessment period. The success rate of total patients was 94.4% after four weeks. For each groups, the success rate of final assessment at 4th week was 90.5% (group A), 92.3% (group B), and 100% (group C), respectively. No significant difference was observed in the success rate between the treatment methods and period ($p>0.05$). However, the CuRM was the only
method with a 100% treatment success rate (Table 2 and Figure 3). Entire patients in group C was successfully treated within 2 weeks, showing rapid and higher treatment efficacy. In head shaking or Gufoni-Appiani groups, around 10% of patients still showed apogeotropic nystagmus or vertigo and were assigned to treatment failure cases.

DISCUSSION

The most salient finding of our study was that the total number of treatments required for otolith reduction to achieve treatment success was significantly lower in group C (p<0.05). All patients in Group C showed a 100% cure rate at 2 weeks, and the success rate was faster than that of the other treatment methods. Therefore, the CuRM is considered the most effective method for apogeotropic LC-BPPV.

Although various diagnostic methods and treatment modalities have been proposed, confirming the type of apogeotropic LC-BPPV remains difficult. Various types do not all have standard treatments. Due to the discrepancy between the various subtypes, the treatment success rate after various repositioning maneuvers for LC-BPPV is poor (70–80%).[14,21] Indeed, when the Korea Otology Society conducted a surveillance of the treatment modality of apogeotropic LC-BPPV, approximately 20 different treatment modalities were used. It was found that remarkably diverse treatment combinations were used compared to posterior canal BPPV and geotropic LC-BPPV.[20]

Although the prevalence of each LC-BPPV subtype is unknown, it is assumed that the utricular form is more common. Shim et al. suggested that in the natural progression of LC-BPPV, apo-type patients experienced substantially faster symptom relief than geo-type patients. The faster symptom remission in apo LC-BPPV than in Geo LC-BPPV suggests that the utricular type of cupulolithiasis (CUP-U) may be the main cause of apo LC-BPPV rather than the canal type of cupulolithiasis (CUP-C) or the canalithiasis in the anterior arm of the LC
Ramos et al. classified 3 subtypes of apogeotropic type of LC-BPPV based on nystagmus observed during 1st and 2nd step of Zuma’s treatment maneuver.[23] If the particles were situated in the anterior arm of the LC (CAN), there will be a transient nystagmus with contralesional direction at step 1 & 2. If the particles were CUP-C subtype, there will be a prolonged nystagmus with contralesional direction at step 1 & 2. In the case of CUP-U subtype, persistent nystagmus will be observed in step 1 & 2, and the direction of nystagmus will be changed as being toward contralesional at step 1 and ipsilesional at step 2. In their study of 18 patients, CAN subtype was found in 8 patients, CUP-C subtype was found in 6 patients, and CUP-U subtype was found in 3 patients. The pathway to the utricle is particularly short in the CUP-U subtype, which may result in spontaneous symptom remission. They hypothesized that this was the reason why utricular side cupulolithiasis was observed in the fewer patients in their study.[8]

The 360-degree canalith repositioning procedure[13], Kim’s maneuver[14] and Zuma’s maneuver[23] can treat all three types with one method. However, the type is unknown in advance, and the direction of nystagmus should be observed in the supine and opposite side laying positions throughout treatment. The Gufoni-Appiani method can be applied to the treatment of the CUP-C or CAN. The Modified Semont maneuver would be useful in the treatment of the CUP-U.[15] Gufoni-Appiani and forced prolonged position, therapeutic head shaking maneuver are a deliberating maneuver. The maneuver itself drops the otolith, but it can be considered a therapeutic maneuver as it enters the utricle while returning to a sitting position.

A recent study assessed the therapeutic efficacy of CuRM in apogeotropic LC-BPPV compared with the THS and modified Lempert maneuvers. They conducted a double-blinded randomized prospective study and found no significant differences in the clinical characteristics among the three groups. Therapeutic effects on the 2nd day and one week after
treatment did not differ among the three groups.[17] This previous study showed results similar to those of our study. Our study also showed no significant differences among the three groups. However, differences were observed between the previous study and our study regarding the observation period and recovery rate. In our study, Group C showed a treatment success rate of 100% after two weeks, which means that treatment with a vibrator can be considered the best treatment. After four weeks of treatment, all treatments showed more than 90% recovery, which is thought to be mixed with the progress of natural recovery. Meanwhile, Kim et al. evaluated 78 patients with persistent apogeotropic LC-BPPV and performed the CuRM. The treatment success rate was 97.4%, and the average number of repetitions was 2.1, which is similar to our results. The authors suggested that the CuRM is an effective method for treating apogeotropic LC-BPPV.[14]

The success rate of THS has few reports. Oh et al. evaluated the therapeutic efficacy of the proposed maneuvers in apogeotropic LC-BPPV in a prospective randomized trial. They compared the immediate efficacies of THS and modified Semont maneuvers in 103 consecutive patients with apogeotropic LC-BPPV. They showed that THS was more effective than the modified Semont maneuver (37.3 vs. 17.3%, P = 0.02). The ability of THS to alternately accelerate and decelerate to separate the otoliths from the cupula may account for its superiority as the first treatment of apogeotropic LC-BPPV, regardless of the attached side.[9] Kong et al. reported a resolution rate of 12.5% following a single application of the THS technique on the first day; however, the success rate increased to 75% after one week.[17] In our study, the initial success rate of THS was 18.2%, and it increased to 71.4% after one week. However, the treatment failure rate of THS was 10.5% in group A in the 4th week, showing a lower failure rate than in other studies. These differences may be due to differences in treatment periods.

Several studies have been conducted on the Gufoni-Appiani maneuver. Appiani evaluated the effectiveness of the Gufoni-Appiani maneuver in treating the apogeotropic LC-
BPPV. All patients were treated using a repositioning procedure based on the presence of free-floating dense particles in the endolymph of the anterior arm of the lateral canal. The LC-BPPV in all patients changed from an apogeotropic to a geotropic variant after the repositioning procedure. It encourages the otolith to move from the anterior into the posterior arm of the lateral canal. [10] Kim et al. conducted a randomized, prospective, sham-controlled study to evaluate the therapeutic efficacy of Gufoni-Appiani and head-shaking maneuvers in apogeotropic LC-BPPV. The patients were randomized to the Gufoni-Appiani (n = 52), head-shaking (n = 54), or sham maneuver (n = 51) groups and had weekly follow-ups for one month after the initial maneuver. Compared with the sham maneuver, the cumulative therapeutic benefits of the Gufoni-Appiani (p < 0.001) and head-shaking maneuvers were also better (p = 0.026). However, neither the short-term (p = 0.128) nor long-term (p = 0.239) results significantly differed between the Gufoni-Appiani and head-shaking groups regarding therapeutic efficacy. [24]

The effectiveness of oscillations during repositioning maneuvers has been debated. Mastoid oscillations were applied to the affected ear during the particle repositioning maneuver to return the otoliths to the utricle by preventing them from adhering to the cupula or canal. [25, 26] While performing the repositioning maneuver, Li suggested the significance of oscillations while performing a repositioning maneuver. In their prospective study, 70% of the patients in the vibration group experienced nystagmus resolution compared to none in the vibration-free group. [25] However, Oh et al. conducted mastoid oscillation concurrent with the Brandt-Daroff exercise and found no additional benefit in patients with apogeotropic LC-BPPV. [9] The other previous studies have shown no significant effect of mastoid ossification. [26, 27] Furthermore, the CuRM demonstrated the best treatment success rate of 38.9% after initial application on the first day. The resolution rate of CuRM demonstrated a significant improvement on the second day. The most effective repositioning of both otoliths in the anterior...
arms of the LC and detachment of the otoliths from the cupula by oscillation is thought to be the result of their treatment success.

This study has several limitations. First, a relatively small number of samples were collected for each cohort. Future research with a larger number of participants will be required. Second, the previous literature reported a male-to-female sex ratio of 1:2 or 1:3 according to the clinical characteristics of BPPV. However, the gender ratio was reversed, with a male predominance of 2.1:1 in this study. The prevalence of LC-BPPV is around 10% of all BPPV, and among them, apogeotropic LC-BPPV is a less frequently encountered condition. For this reason, the male-to-female ratio appears to be reversed. Third, there may have been a selection bias in the composition of the study sample. Category 1 therapy (THS and Gufoni-Appiani) simply deliberates the otolith from the cupula rather than completely remove it from the canal, so its therapeutic efficacy may be weaker than the other 2 maneuvers. However, category 2 therapy (CuRM) involves simultaneously dropping the otolith and repositioning, so treatment efficacy might be higher than the other 2 maneuvers. Fourth, the subtypes of LC-BPPV are difficult to differentiate at the time of diagnosis. Although the subtype can be predicted while undergoing treatment, more research on subtype diagnosis will be beneficial for treating apo LC-BPPV patients.

We performed a multicenter, randomized, controlled study to validate the efficacy of oscillations for persistent apogeotropic LC-BPPV. We compared the therapeutic efficacy of CuRM with other therapeutic maneuvers. We conclude that oscillation, as demonstrated by CuRM results, successfully separated otoliths from the cupula. Although no difference was observed between the groups in the recovery rate after one month of follow-up, group C had the fastest and highest recovery rates and the lowest number of times.
CONCLUSION

There is no clear difference between the three treatments for LC-BPPV, but CuRM is relatively superior to the other treatments in the long term.

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Conflict of interest: The authors declare no conflicts of interest.

Highlight

1. The apogeotropic form of LC-BPPV is caused by free-floating particles in the anterior arm of the LC, particles attached to the cupula in the canal, or particles attached to the cupula in the utricle.

2. There is no significant difference in the treatment success rate between the three treatments for apogeotropic LC-BPPV.

3. CuRM is relatively superior to the other treatments in the long term.

References


Figure 1. Flow diagram for the effects of various otolith reduction techniques in patients with apogeotropic lateral semicircular benign paroxysmal positional vertigo.

n: number, THS: Therapeutic head shaking, CuRM: Cupulolith repositioning maneuver

SRT: Supine roll test

Figure 2. A schematic illustration of the study design.

n: number, THS: Therapeutic head shaking, CuRM: Cupulolith repositioning maneuver

SRT: Supine roll test

Figure 3. The success rate of each otolith reposition maneuver

THS: Therapeutic head shaking, CuRM: Cupulolith repositioning maneuver

Total: The average success rate of the three treatments
Table 1. Demographic and clinical data of the enrolled patients.

<table>
<thead>
<tr>
<th></th>
<th>THS (n=22)</th>
<th>Gufoni-Appiani (n=26)</th>
<th>CuRM (n=24)</th>
<th>Total (n=72)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender (M:F, n)</td>
<td>14:8</td>
<td>19:7</td>
<td>16:8</td>
<td>49:23</td>
<td>0.771</td>
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<tr>
<td>Age (mean±SD)</td>
<td>54.6±14.7</td>
<td>56.0±13.6</td>
<td>55.5±12.8</td>
<td>55.4±13.5</td>
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<tr>
<td>Side (R:L, n)</td>
<td>15.7</td>
<td>17.9</td>
<td>14.10</td>
<td>46.26</td>
<td>0.770</td>
</tr>
<tr>
<td>Vertigo duration (days)</td>
<td>4.9±5.3</td>
<td>4.7±4.8</td>
<td>2.3±2.4</td>
<td>3.9±4.4</td>
<td>0.069</td>
</tr>
<tr>
<td>Latency of nystagmus (s)</td>
<td>3.8±3.2</td>
<td>2.8±3.6</td>
<td>1.6±1.5</td>
<td>2.7±3.0</td>
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<tr>
<td>Duration of nystagmus (s)</td>
<td>48.9±16.1</td>
<td>46.8±15.6</td>
<td>48.2±16.3</td>
<td>47.9±15.8</td>
<td>0.898</td>
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<tr>
<td>Number of treatment</td>
<td>2.1±0.9</td>
<td>2.3±0.9</td>
<td>1.7±0.7</td>
<td>2.0±0.9</td>
<td>0.044*</td>
</tr>
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*p<0.05, THS: Therapeutic head shaking, CuRM: Cupulolith repositioning maneuver


Table 2. Success rate of the otolith reposition maneuver

<table>
<thead>
<tr>
<th></th>
<th>THS (n=22)</th>
<th>Gufoni-Appiani (n=26)</th>
<th>CuRM (n=24)</th>
<th>Total (n=72)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial</td>
<td>4 (18.2%)</td>
<td>2 (7.7%)</td>
<td>8 (33.3%)</td>
<td>14 (19.4%)</td>
<td>0.072</td>
</tr>
<tr>
<td>Week 1</td>
<td>15 (71.4%)</td>
<td>18 (69.2%)</td>
<td>21 (87.5%)</td>
<td>54 (76.1%)</td>
<td>0.267</td>
</tr>
<tr>
<td>Week 2</td>
<td>16 (76.2%)</td>
<td>22 (84.6%)</td>
<td>24 (100%)</td>
<td>18 (83.3%)</td>
<td>0.050</td>
</tr>
<tr>
<td>Week 3</td>
<td>19 (90.5%)</td>
<td>23 (88.5%)</td>
<td>24 (100%)</td>
<td>66 (93.0%)</td>
<td>0.244</td>
</tr>
<tr>
<td>Week 4</td>
<td>19 (90.5%)</td>
<td>24 (92.3%)</td>
<td>24 (100%)</td>
<td>67 (94.4%)</td>
<td>0.327</td>
</tr>
</tbody>
</table>

THS: Therapeutic head shaking, CuRM: Cupulolith repositioning maneuver
Figure 2

**Treatment group**
- Group 1 (n=22) : THS
- Group 2 (n=26) : Gufoni-Appiani maneuver
- Group 3 (n=24) : CuRM

1st assessment (SRT after 20 minutes)
- Recovery: No nystagmus
- Geotropic
  - Nystagmus: Barbecue maneuver or Gufoni maneuver
- Apogeotropic
  - Nystagmus: Repeat same treatment for each group

Assessment (1, 2, 3 weeks, SRT)
- Recovery: No nystagmus
- Geotropic
  - Nystagmus: Barbecue maneuver or Gufoni maneuver
- Apogeotropic
  - Nystagmus: Repeat same treatment for each group

Final assessment (5 weeks)
- Recovery: No nystagmus
- Geotropic
  - Nystagmus: Barbecue maneuver or Gufoni maneuver
- Apogeotropic
  - Nystagmus: Treatment failure
Figure 3