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Original Article

Universal Repositioning Maneuver: A New Treatment for Single Canal and Multi-Canal Benign Paroxysmal Positional Vertigo by 3-Dimensional Model Analysis

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BACKGROUND: Benign paroxysmal positional vertigo is the most common peripheral vestibular disorder and is currently treated by many types of repositioning maneuvers. A simplification of this procedure would be desirable. A new, anatomically realistic, 3-dimensional computational simulator of the human labyrinth provides a novel insight to evaluate the viability of any new maneuver. The purpose of this study is to propose a single maneuver with potential to treat canalolithiasis-type benign paroxysmal positional vertigo of any individual canal, or even multiple canals on the same side, based on a 3-dimensional model.

METHODS: The benign paroxysmal positional vertigo Viewer, a 3-dimensional model of the human labyrinth, was used to analyze a "Universal Repositioning Maneuver."

RESULT: Through the gravity vector, the expected position of the otoliths was demonstrated by moving the model through a single sequence of head positions, successfully promoting otolith migration from the three semicircular canals to the utricular cavity, either individually or together.

CONCLUSION: The analysis with the 3-dimensional model predicts the effectiveness of the Universal Repositioning Maneuver for the resolution of each single canal or multiple-canal benign paroxysmal positional vertigo canalolithiasis, making treatment much more straightforward.

KEYWORDS: Dizziness, maneuver, multicanal BPPV, single canal BPPV, treatment, vertigo

INTRODUCTION

Benign paroxysmal positional vertigo (BPPV) is the most common peripheral vestibular disorder, with a higher prevalence in women.[1] Typically, it presents with brief and recurrent episodes of vertigo caused by changes in the head position in relation to gravity.[1]

Benign paroxysmal positional vertigo is thought to be generated by free-moving otoliths (or fragments of otoliths) dislodged from the utricular maculae.[2] This debris can move freely inside the endolymphatic system and can migrate to any semicircular canal (canalolithiasis). In the typical canalolithiasis variant of BPPV, the free-floating particles within the lumen of the canal induce an

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aberrant signal from the semicircular canals creating the illusion of motion which results in both a symptom (vertigo) and a physical examination sign (nystagmus).[3]

In addition, it is worth remembering that the cases of multicanal BPPV are possible, representing 5%-10% of occurrences, and the current therapeutic approach aims to resolve one semicircular canal separately. Although such an approach can be effective, it increases the time of care, and consequently can provoke greater symptoms, since different maneuvers will be applied for each repositioning needed, and that may require treatment over several days.[4-6]

Until the 1980s, BPPV management focused on raising awareness and patient reassurance, informing them about its benign nature and possible spontaneous resolution. Thus, guidelines to avoid sudden movements and specific positions were given in order to minimize the onset of vertigo attacks[7]—this strategy was basically one of trigger avoidance.

Shortly thereafter, therapeutic maneuvers emerged aiming at the repositioning of the otoliths (generically called "canalith repositioning maneuvers"), and this approach started focusing on the treatment of BPPV of the posterior semicircular canal. Epley's maneuver[8] and Semont's maneuver[9] were the first to be presented as effective for BPPV of the posterior semicircular canal in the form of canalolithiasis and cupulolithiasis, respectively.[7] Over the years, many other maneuvers have been presented, and thorough studies have proven their effectiveness. However, they are almost always linked to the resolution of a specific BPPV situation, that is, the repositioning of the otoliths of a specific semicircular canal.[10-12]

In the United States, there are approximately 200 000 new cases of BPPV annually[13]; however, specialized care (such as by a vestibular rehabilitation, consultation with an otoneurologist or neurotologist) is not widely available. In addition, the knowledge of the many maneuvers and their indications is not a reality for many professionals, especially in emergency care units.[14,15] Thus, even when a patient with BPPV is being evaluated by a clinician, nonspecialist practitioners are hesitant to treat, either because they are not confident about identifying the affected canal, or they are not comfortable choosing or performing the appropriately targeted therapeutic maneuver,[16] not to mention that most maneuvers are not easily performed by patients with physical limitations.[17]

In view of these considerations, it would be desirable to have a single repositioning maneuver that could treat single canal BPPV and/or ipsilateral multicanal BPPV. This would streamline care by making it easier for nonexpert clinicians to treat and could potentially accelerate symptom resolution. Analyzing previous clinically well-proved maneuvers, supported by a biomechanical model, we observed that a new canalith repositioning maneuver was able to move otoliths from any single canal back to the utricular sac, as well as otoliths simultaneously present in multiple canals on one side. So this study attempted to determine the theoretical feasibility of a new maneuver to treat canalolithiasis-type BPPV of any individual canal or even multiple canals on the same side based on a three-dimensional (3D) computational model.

METHODS

The BPPV Viewer (BPPVViewer.com), a 3-dimensional (3D) biomechanical model of the human labyrinth system designed for the study of BPPV,[18] was used to test the Universal Repositioning Maneuver in the treatment of the BPPV-canalolithiasis of 1 of the 3 semicircular canals on a given side, or even multicanal BPPV simultaneously affecting 1 side.

This 3D biomechanical model, created from axial histological sections of a human labyrinth, was based on the same technique used to create the Temporal Bone Downloadable Virtual Model[19] and through high-resolution scanning and integrated into Amira 5.2.2 (Thermo Fisher Scientific Inc., OR, USA), making it possible to photograph the histological sections. The reconstructed labyrinth was reflected to the other side and thus positioned relative to a 3D surface map of a human skull. Finally, virtual mobile markers were created to represent the otoliths and their location according to the cephalic position.[20]

Using the model's gravity function, the expected position of the otoliths was demonstrated by moving the model through sequential positions of Universal Repositioning Maneuver. These steps were individually and systematically adjusted to identify a single sequence that met the objective of repositioning otoliths from the 3 semicircular canals to the utricle (canalith repositioning).

Screenshots of the model demonstrating the repositioning were taken for the publication of this article.

This study analyzed, through a 3D model, the effectiveness of the Universal Repositioning Maneuver. There was no participation of human beings and/or animals; therefore, documents of informed consent and approval by the Ethics Committee were not necessary.

RESULTS

The Universal Repositioning Maneuver sequence is demonstrated in Figure 1 (illustration of the maneuver):

The 3D model (Figures 2-6) estimates the position of the otoliths expected at different orientations of the head in a sequential fashion in a single canal BPPV—canalolithiasis type: posterior canalolithiasis (Figure 2), lateral canalolithiasis of the nonampullary arm (Figure 3), and of the ampullary arm (Figure 4), anterior canalolithiasis (Figure 5), and in a multicanal BPPV (Figure 6). The yellow ball represents the otolith inside the semicircular canal.

The maneuver proposed here draws on the Li Maneuver,[21] the Gans Maneuver,[22] the Kim Maneuver,[23] and the Zuma Maneuver,[24] with some modifications in order to promote the clearance procedure in any of them.

DISCUSSION

The existence of a single maneuver to treat BPPV may facilitate the canalith repositioning procedure for nonspecialist professionals and even for a specialist who is already familiar or not with the diagnostic and therapeutic routine. This knowledge can be valuable as it would "simplify" clinical practice in relation to the choice and applicability of the many maneuvers for canalolithiasis-type BPPV single canal, as well as for the involvement of multiple canals on the same side.

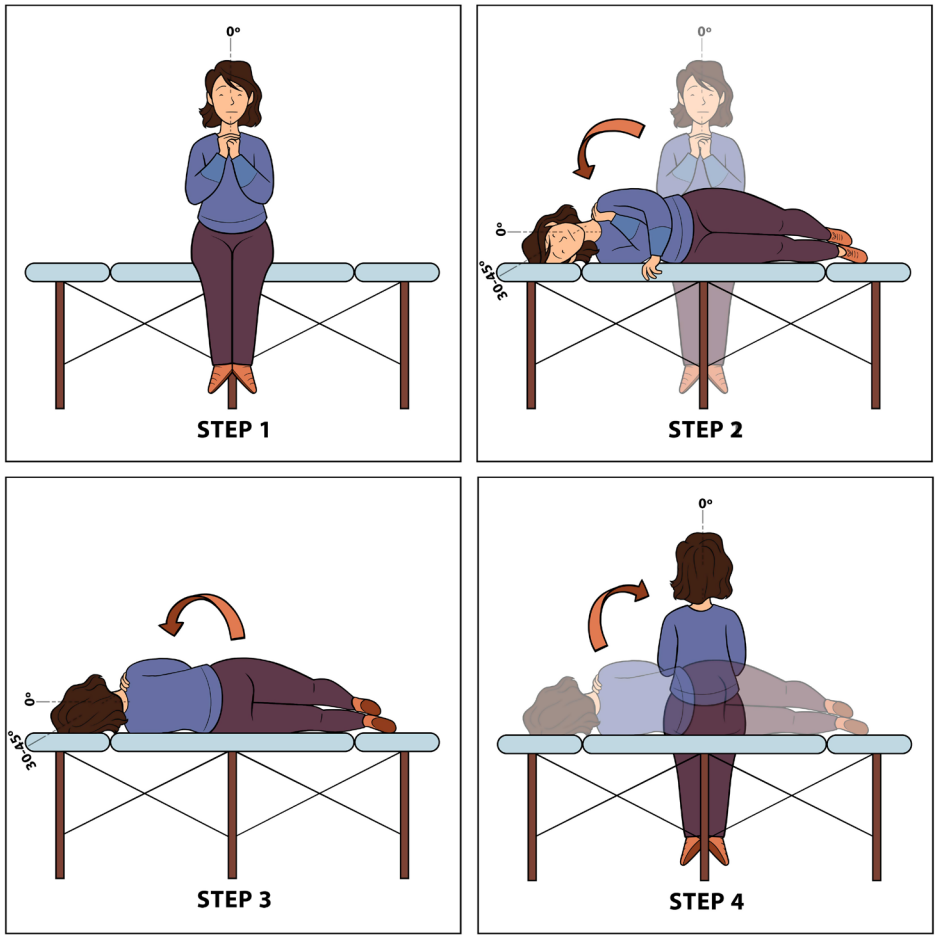

Figure 1. Universal Repositioning Maneuver for the treatment of single canal and multicanal BPPV—Canalolithiasis type, right side—4-step sequence. Step 1: Patient sitting with head neutral (0°) legs hanging down. Step 2: Patient is lying on right shoulder, with head laterally flexed 30°-45° (The head is not horizontally rotated around the patient's vertical axis). Step 3: Patient rolls 180° to the unaffected side, lying on the left shoulder, with head laterally flexed 30-45°. Step 4: Patient sits up keeping the head neutral (0°). BPPV, benign paroxysmal positional vertigo.

The situation of multicanal BPPV is not often discussed, and the clinical practice for the resolution of BPPV is usually longer and can provoke greater symptoms, since 1 semicircular canal is treated at a time.[5,6] The minimum recommended time between treatment for each semicircular canal is at least 3 hours,[5] and given clinic scheduling constraints, treatment may require multiple days for the repositioning of multicanal BPPV. The symptoms provoked during this time can also increase the risk that a patient would discontinue therapy for fear of feeling ill during multiple treatment maneuvers.

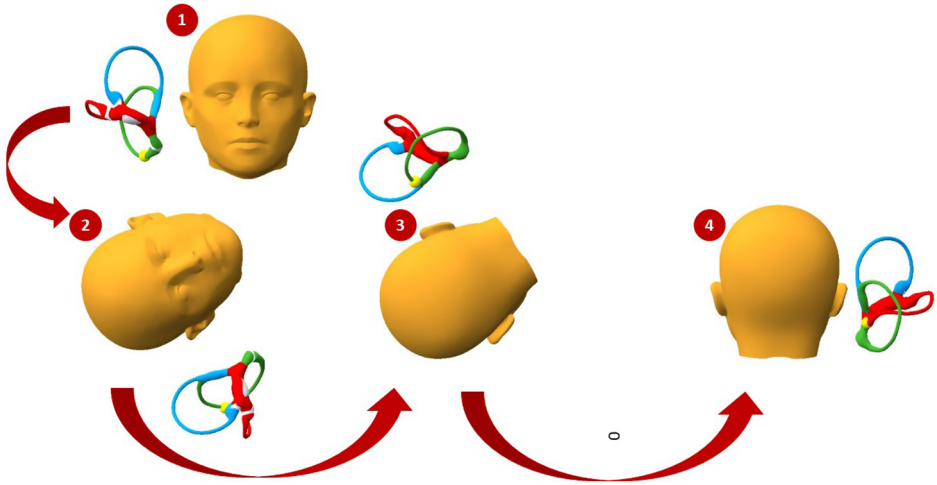

Figure 2. Simulation of the 3D model of the Universal Repositioning Maneuver for the treatment of BPPV of the posterior semicircular canal—canalolithiasis type, on the right side—sequence of 4 steps. BPPV, benign paroxysmal positional vertigo.

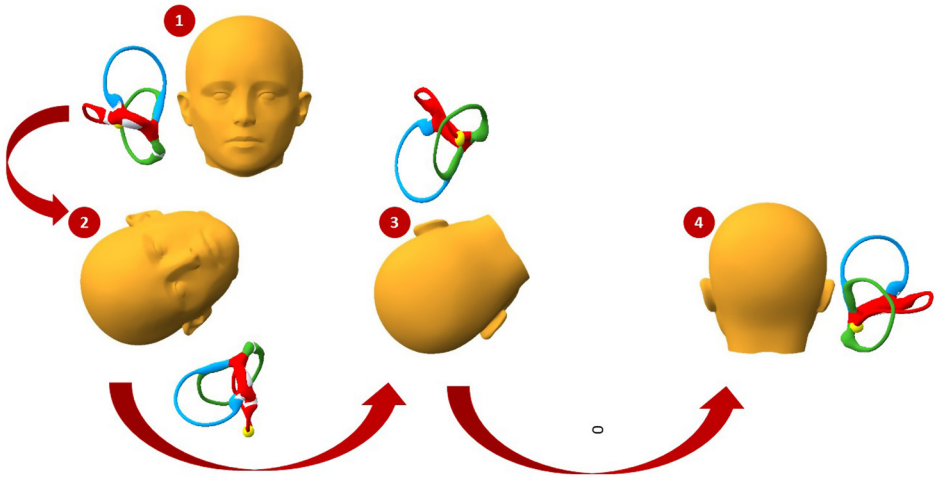

Figure 3. Simulation of the 3D model of the Universal Repositioning Maneuver for the treatment of BPPV of the lateral semicircular canal—canalolithiasis type nonampullary arm on the right side—sequence of 4 steps. BPPV, benign paroxysmal positional vertigo.

In cases of multicanal BPPV, the order of treatment is usually according to the intensity of the symptoms and the nystagmus signal caused by the affected channels. Based on this information, the prioritized order is lateral canal, posterior canal, and anterior canal.[5] However, many practitioners choose to start repositioning of the posterior canal because in some cases, treatment of posterior canal BPPV results in conversion to lateral canal involvement. In this way, an attempt is made to optimize the relationship between treatment time and triggered clinical manifestations.[6] Canal switching can occur during the retesting procedure.[25]

The Universal Repositioning Maneuver is an appropriate option for these multicanal BPPV situations, as its execution will act simultaneously on the affected semicircular canals, without the need to choose the order of multiple repositioning maneuvers, thereby reducing the total treatment time and the risk of treatment abandonment, returning the patient to their premorbid level of function more quickly.

A potentially useful modification of the Universal Repositioning Maneuver could involve using a sheet and/or towel under the patient's torso in order to facilitate the transition from step 2 to 3, as already utilized in the Gans maneuver. This small detail is of great value to patients with physical limitations for body rolling, as well as for professionals who find it difficult to execute this movement.[26] In addition, rolling 180° to the unaffected side can be facilitated with the therapist positioned behind the patient during step 1, holding his left hand and thus pulling him to his side, step 2, as too already demonstrated in the Li maneuver for the lateral canal.[27]

For patients experiencing difficulty achieving the correct angles of head inclination, setting a pillow under the shoulder of the affected side would be reasonable. Another strategy following the same facilitative idea is to lie laterally on the shoulder on the affected side, however, tilting the head out of the stretcher/bed. This can make it easier to reach the ideal position of the Universal Repositioning Maneuver. The above modifications did not affect the migration of the particles according to the 3D models.

Additionally, the Universal Repositioning Maneuver offers an alternative for those with restricted cervical mobility in extension and rotation because the only cervical movement required in this maneuver

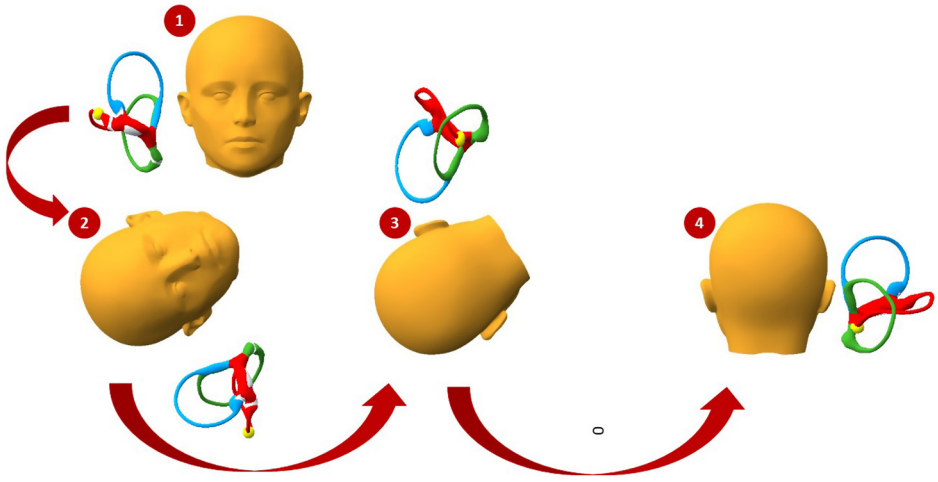

Figure 4. Simulation of the 3D model of the Universal Repositioning Maneuver for the treatment of BPPV of the lateral semicircular canal—canalolithiasis type ampullary arm, on the right side—sequence of 4 steps. BPPV, benign paroxysmal positional vertigo.

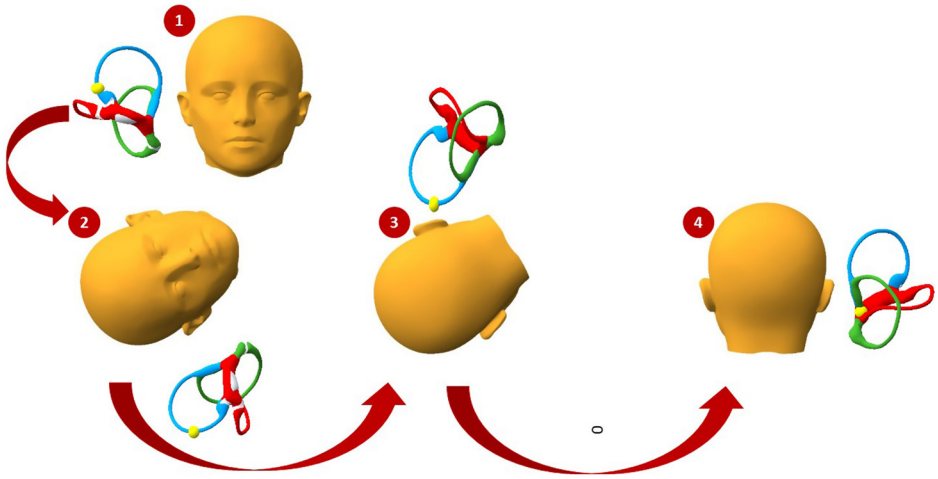

Figure 5. Simulation of the 3D model of the Universal Repositioning Maneuver for the treatment of BPPV of the anterior semicircular canal—canalolithiasis type, on the right side—sequence of 4 steps. BPPV, benign paroxysmal positional vertigo.

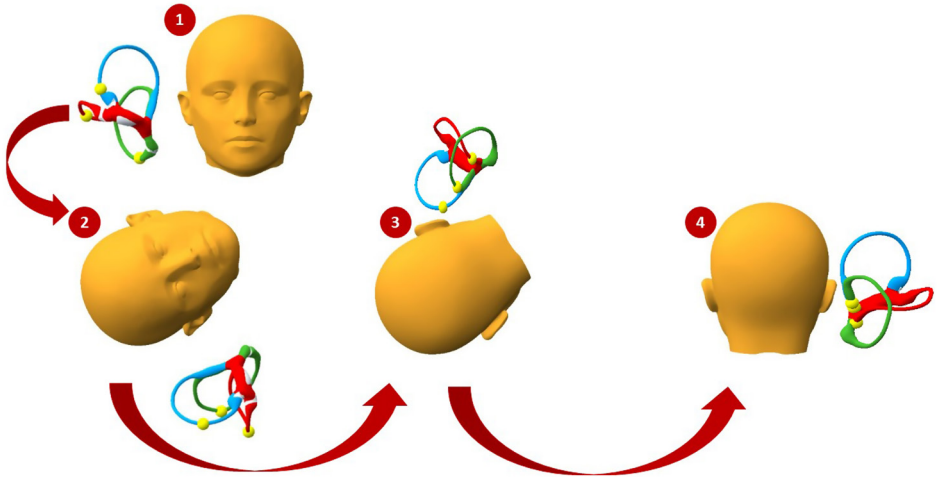

Figure 6. Simulation of the 3D model of the Universal Repositioning Maneuver for the treatment of multicanal BPPV—canalolithiasis type, on the right side—sequence of 4 steps. BPPV, benign paroxysmal positional vertigo.

is the head tilt (lateral flexion). Finally, the simplicity of execution may also make it a viable alternative strategy for management of BPPV, either through self-treatment, or via the increasingly used modality of telehealth.[28]

Since the experimental maneuver described here would work for any ipsilateral canalolithiasis, all that is required is identification of the affected ear. It is worth noting that the Universal Repositioning Maneuver analysis was also performed considering that it was started on the unaffected side. It was observed that channel conversion does not occur, but rather a process of movement of the otoliths in a backward and forward direction (interspersing ampullopetal and ampullofugal stimulations), resulting in the permanence of otoliths at the same initial point (failure). All professionals (experts or non-experts) should still follow the known instructions for determining the affected side and thus proceed with the Universal Repositioning Maneuver as instructed, starting with the affected side. However, such information is useful because if it is mistakenly applied to the unaffected side, and there will be no replacement of the otoliths, consequently, the signs and symptoms will remain during the reassessment, but there will only be the other side (affected side) to perform it.

Limitations

The analysis with the 3D model predicts the efficacy of the Universal Repositioning Maneuver, but the validation of the proposed hypothesis should be tested by observational studies, and the effectiveness should be measured by randomized controlled trials.

CONCLUSION

Based on results from simulation through a 3D virtual model, we propose the Universal Repositioning Maneuver as a new treatment for canalolithiasis-type BPPV involving any of the three semicircular canals and even multicanal canalolithiasis of the same side.

The process of validating the hypothesis has already begun in our institution. If confirmed by other study designs, the proposed maneuver could facilitate the clinical practice of specialists and non-specialist professionals alike, including those who work in urgent care or emergency departments and general practice.

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Informed Consent: N/A.

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