

# Affected-Ear-Up 90° Maneuver Proves That Nystagmus Does Not Occur by the Stimulation to the Macula of the Utricle

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## Abstract

**Background:** The utricular macula is located on the floor of the utricle, approximately in the plane of the lateral semicircular canal, and is oriented to respond best to lateral tilts and side-to-side or fore-and-aft translations of the head. However, the details of the otolith ocular reflex are unknown. Pathophysiology of transient direction-changing geotropic positional nystagmus is a canalolithiasis in the lateral semicircular canal. The principle of affected-ear-up 90° maneuver is moving debris from a long arm to the utricle, therefore debris stimulates the utricular macula in the sitting position after the treatment. **Objective:** To clarify whether nystagmus occurs by the stimulation to the macula of the utricle. **Methods:** The subjects were 10 patients with lateral semicircular canal canalolithiasis. After the diagnosis, we performed affected-ear-up 90° maneuver immediately. We observed eye movements in the sitting position (chin-down 30°) just after the treatment. **Results:** No one showed nystagmus in the sitting position after the treatment. In all patients, positional nystagmus disappeared within 7 days after the treatment. **Conclusion:** Nystagmus does not occur by the stimulation to the macula of the utricle. Hence, we cannot assess the function of the utricle by the analysis of eye movements, and ocular counter-rolling is considered to be a semicircular canal ocular reflex.

## Keywords

Benign Paroxysmal Positional Vertigo, Canalolithiasis, Ocular Counter-Rolling, Otolith Ocular Reflex, Lateral Semicircular Canal

## 1. Introduction

Benign paroxysmal positional vertigo is classified into a lateral semicircular can-

al type and a posterior semicircular type, according to the features of positional nystagmus. Patients with the lateral canal type show horizontal nystagmus, and patients with the posterior canal type reveal torsional nystagmus. Positional nystagmus of the lateral canal type is classified as direction-changing geotropic nystagmus or direction-changing apogeotropic nystagmus. Geotropic nystagmus is classified into transient type or persistent type. Canalolithiasis (moving debris) accounts for transient geotropic nystagmus [1] [2], and persistent type, which lasts more than 1 minute, is caused by a light cupula [3] [4] [5]. Apogeotropic nystagmus is persistent and explainable by a cupulolithiasis [6].

We can treat patients with lateral canalolithiasis by the affected-ear-up 90° maneuver [7]. The principle of it is the movement of debris from the long arm to the utricle, which stimulates the utricular macula in the sitting position after the treatment. Therefore, we can confirm whether nystagmus occurs from the utricle by observing eye movements just after the treatment.

The utricular macula is located on the floor of the utricle, approximately in the plane of the lateral semicircular canal, and is oriented to respond best to lateral (ear to shoulder) tilts and side-to-side or fore-and-aft translations of the head. However, the details of the otolith ocular reflex are unknown. In animal experiments, electrical stimulation of the utricular nerve produced various patterns of eye movements. Suzuki *et al.* [8] reported that there was a vertical deviation of the optic axes (skew deviation) and a horizontal deviation, in addition to a torsional component. Moreover, Goto *et al.* [9] reported that horizontal eye movements were evoked. However, there is not a physiological consensus regarding otolith ocular reflex.

The aim of the present study was to clarify whether nystagmus occurs by the stimulation of unilateral macula of the utricle.

## 2. Methods

### 2.1. Subjects

The subjects were 10 patients with lateral semicircular canal canalolithiasis who visited our institution between February 2021 and January 2023. All subjects gave informed consent to participate in the study.

### 2.2. Inclusion Criteria

Supine head roll test reveals following findings. There is no nystagmus in the sitting position. In the supine position, transient lying-down nystagmus frequently occurs [7]. In the right-ear-down position, horizontal nystagmus toward the right occurs after a brief period, and then decays and stops within 1 minute. In the left-ear-down position, horizontal nystagmus toward the left occurs after a brief period, and then decays and stops within 1 minute.

### 2.3. Exclusion Criteria

Patients with central nervous system disorders were excluded.

## 2.4. Nystagmus Testing

Supine head roll test was performed in the dark with the patients' eyes open using an infrared charge-coupled device camera.

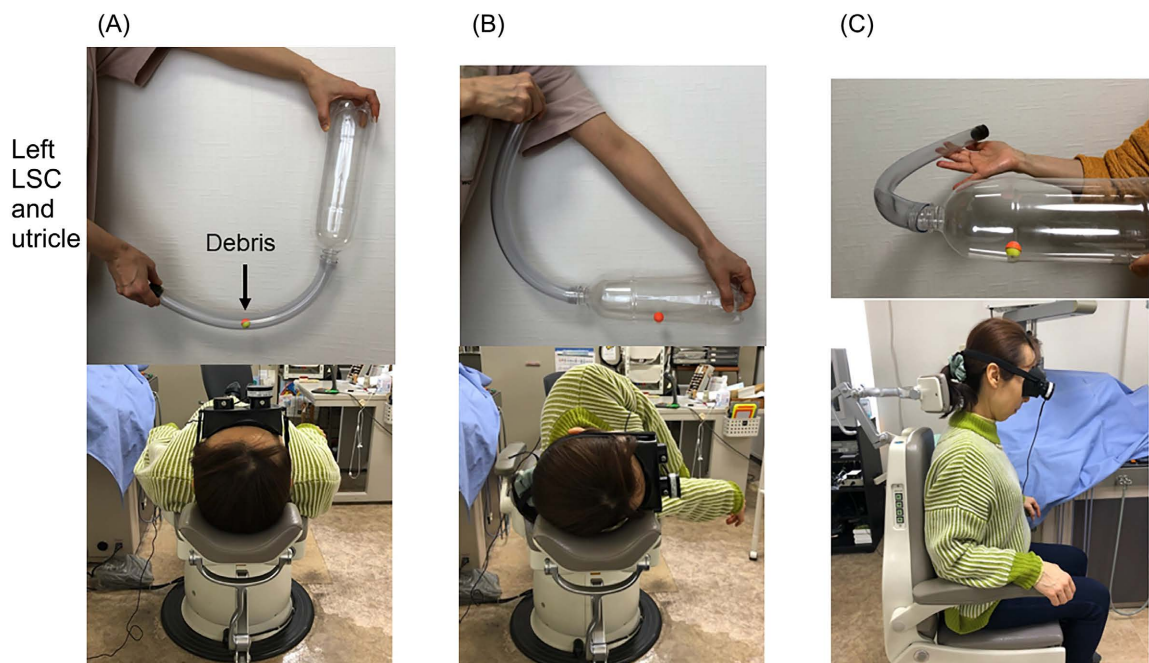
## 2.5. Determining the Affected Side

The affected side was assessed by comparing the intensity of nystagmus. If leftward nystagmus was stronger than rightward nystagmus, the left side was considered to be affected. In cases in which symmetrical nystagmus was seen, we determined the affected side based on the direction of transient lying-down nystagmus; *i.e.*, if lying-down nystagmus toward the right was seen, the left side was considered to be affected.

## 2.6. Treatment

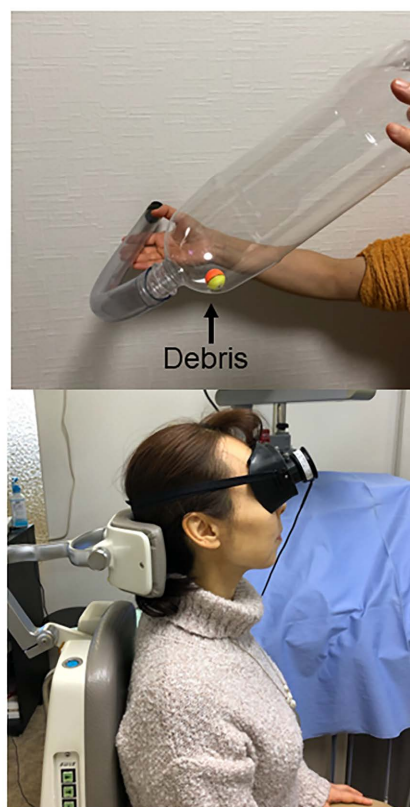
After determining the affected side, we immediately performed the affected-ear-up 90° maneuver (Figure 1). This maneuver is performed as follows:

- 1) Place the patient in the supine position.
- 2) Rotate the head toward the healthy side until it is located 90° from the supine position and hold the position until the nystagmus stops.
- 3) Ask the patient to sit up (chin-down 30°).
- 4) Raise the head (chin-up 30°) to confirm the repositioning of the pathological debris (Figure 2).
- 5) Ask the patient to remain upright with the chin-down 30° until night.



**Figure 1.** Affected-ear-up 90° maneuver. Affected side is the left in this picture. (A) Place the patient in the supine position. (B) Rotate the head toward the right side until it is located 90° from the supine position and hold the position until the nystagmus stops. (C) Ask the patient to sit up and remain upright with the chin-down 30° until night. LSC = lateral semicircular canal.

Left  
utricle



**Figure 2.** Chin-up 30° maneuver can confirm the repositioning of the pathological debris. If affected-ear-up 90° maneuver is successful, nystagmus does not occur because the debris stays in the utricle.

### 2.7. Follow-Up

At the second visit (within 7 days), we performed the supine head roll test again, and interviewed concerning residual dizziness.

## 3. Results

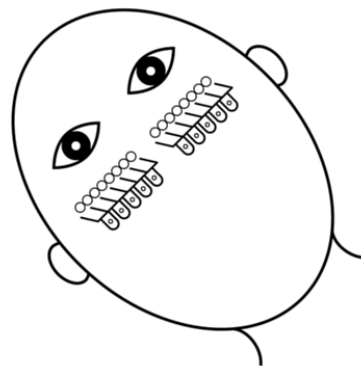
All patients were female and over fifties. Just after the treatment, none of the patients showed nystagmus in the sitting position, and none complained of dizziness. In all patients, positional nystagmus disappeared within 7 days after the treatment (**Table 1**). There were no complaints of residual dizziness.

## 4. Discussion

We found that nystagmus does not occur by stimulus to the unilateral macula of the utricle. By chin-up 30° maneuver (**Figure 2**), we confirmed that pathological debris returned to the utricle. If determining of the affected side is wrong, transient horizontal nystagmus occurs because debris locates in the long arm. In all patients, as both positional nystagmus and dizziness disappeared within 7 days after the treatment, the debris returned to the utricle. Despite the debris stimulating the macula of the utricle, nystagmus did not occur. This phenomenon is a novel finding regarding otolith ocular reflex.

**Table 1.** Results. SHT = supine head roll test. F = female. R = right. L = left.

Patient	Age (years)	Sex	Affected side	Just after treatment			Re-visit	
				Nystagmus (Chin-down 30°)	Nystagmus (Chin-up 30°)	Dizziness	Nystagmus (SHT)	Dizziness
1	51	F	R	—	—	—	—	—
2	54	F	L	—	—	—	—	—
3	59	F	R	—	—	—	—	—
4	61	F	R	—	—	—	—	—
5	64	F	L	—	—	—	—	—
6	64	F	R	—	—	—	—	—
7	66	F	L	—	—	—	—	—
8	66	F	L	—	—	—	—	—
9	69	F	R	—	—	—	—	—
10	87	F	R	—	—	—	—	—

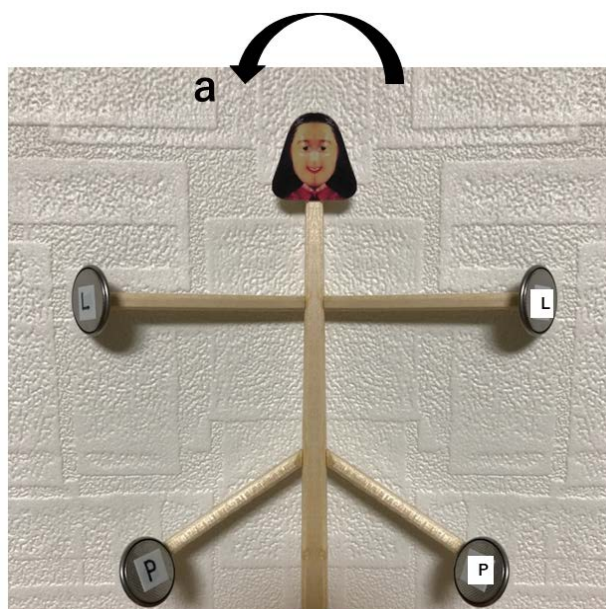


**Figure 3.** When the head is tilted to the right side, otoconia on the utricular macula move to the right side. If utricle ocular reflex occurs, leftward nystagmus should occur in the same fashion as a leftward lineal acceleration; however, nystagmus does not occur in actuality.

Curthoys [10] reported that upward eye movements were evoked by stimulation to the unilateral macula of the utricle using guinea pigs; however, this finding may not be relevant to studies of human responses, because torsional eye movements occur by head tilt in humans.

When the head is tilted to the right ear by 45°, otoconia on the utricular macula move to the right side (Figure 3). If utricle ocular reflex occurs, leftward nystagmus should arise in the same fashion as a leftward lineal acceleration. However, nystagmus does not occur in actuality. This suggests that the utricle does not produce nystagmus. Hence, we cannot assess the function of the utricle by the analysis of eye movements.

Ocular counter-rolling has been considered an otolith ocular reflex; however, our findings do not support this hypothesis. We propose the following mechanism of ocular counter-rolling. The position of the cupula of the lateral canal tilts



**Figure 4.** Position of the four cupulae. When the head is tilted toward the right side (roll rotation), the posterior canals are mainly stimulated by the inertial force. a = angular acceleration. L = lateral canal cupula. P = posterior canal cupula.

toward the lateral side by  $45^\circ$  [11]. Furthermore, the cupula of the posterior canal is also tilted  $45^\circ$ . The positions of the four cupulae are shown in **Figure 4**. When the head is tilted toward the right side (roll rotation), posterior canals are mainly stimulated by the inertial force. Theoretically, rightward torsional nystagmus occurs. Practical eye movement is rightward torsional. Thus, physiologically, we hypothesize that posterior canals produce ocular counter-rolling.

## 5. Conclusion

Patients with lateral canalolithiasis did not complain of dizziness and did not reveal nystagmus just after the affected-ear-up  $90^\circ$  maneuver. These results suggest that the stimulation to the utricle does not produce a giddy feeling and does not produce nystagmus. Therefore, we cannot assess the function of the utricle by the analysis of eye movements, and the ocular counter-rolling is considered to be a semicircular canal ocular reflex.

## Acknowledgements

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## Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

## Ethical Approval

All procedures performed in study involving human participants were in accor-



dance with the ethical board of the Hirosaki Medical Association (reference number is 2022-11) and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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