

Binocular and monocular measurements of subjective visual vertical in vestibular loss

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## Abstract

**Objectives:** To investigate the possibility to omit the time-consuming monocular vision measurement in the subjective visual vertical (SVV) test by demonstrating there is no difference in the results between binocular and monocular measurements.

**Patients:** Thirty-one patients with unilateral vestibular schwannoma and twenty normal subjects as controls.

**Intervention:** Both binocular and monocular measurements of SVV were performed.

**Main outcome measure:** Difference in the results of SVV between binocular and monocular measurements.

**Results:** There were no significant differences in the tilts of the SVV between binocular and monocular measurements in vestibular schwannoma patients as well as in the controls.

**Conclusion:** Abnormal tilts of SVV may be evaluated precisely only by binocular vision instead of monocular vision.

**Keywords:** subjective visual vertical (SVV); binocular measurement; monocular measurement; vestibular loss

## Introduction

As well as skew deviation and ocular torsion (OT), abnormal tilts of the subjective visual vertical (SVV) are often observed when the vestibular system is disturbed (1, 2). In such static abnormalities related to eye movements, SVV is valued as a simple clinical test for evaluating the otolithic function and the graviceptive pathways caused either by peripheral or central vestibular disorders (3, 4).

Visual information is assumed to be important for the examinees to perform the SVV test correctly, because it has an influence on their vertical perception (5, 6). Whichever visual factor may have an influence on verticality perception, little is known about whether binocular or monocular vision has any influence on verticality perception and the sensitivity of SVV. In measuring the SVV of a patient with monocular palsy, monocular measurements of SVV with each eye covered in turn are recommended (1, 7), while others have recommended binocular measurements with both of the subject's eyes open (8). From the viewpoint of a clinical test, if there is no difference in the sensitivity detecting abnormalities in SVV between binocular and monocular measurements, time-consuming monocular measurements can be omitted in a routine vestibular function test.

In the present study, to investigate the possibility to omit the monocular vision measurement in the SVV test by demonstrating no difference in the results between binocular and monocular measurements, we performed monocular and binocular measurements of SVV in both normal subjects and patients with vestibular schwannoma.

### Subjects and Methods

The present study conformed to the Declaration of Helsinki, and ethics committee of Nagasaki University Hospital approved the present study (approval number 090724651). The purpose of the present study was explained to volunteer normal subjects as well as each patient, and informed consent was obtained before measurements.

### Normal Subjects

Twenty volunteer normal subjects without any history of hearing loss, imbalance, or tinnitus, containing 13 men and 7 women with their age ranging from 23 to 42 years with an average of 28.5 years, were enrolled in the present study as controls.

## Patients with Vestibular Schwannoma

Thirty-one outpatients of the Nagasaki University Hospital with unilateral vestibular schwannoma were monitored, 11 men and 20 women were enrolled with an age range of 18 to 80 years and an average of 61.1 years. All subjects gave their informed written consent after the nature of the experimental procedure was explained in accordance with the Declaration of Helsinki. In 13 cases the affected side was on the right and 18 cases on the left. In these 31 patients, the surgery was performed with translabyrinthine approach on 12 patients, with retrosigmoid approach on another 2 patients, and the remaining 7 patients were treated by radiation therapy.

## Vestibular function tests

In all the patients with vestibular schwannoma, electronystagmography, caloric test, and measurements of vestibule-ocular reflex (VOR) gain were performed before the SVV test. In the patients with vestibular schwannoma, whether spontaneous nystagmus was present or not was determined with the use of an infrared video camera (Nagashima Medical Instruments, Tokyo, Japan), and whether ataxia was present or not was evaluated by a Fukuda stepping test (9). In caloric tests, if asymmetry in the response between the left and right ears was greater than 20%, it was defined as the

canal paresis (CP) (Jonkees' formula).

#### Measurement of SVV

All the controls and the 31 patients with vestibular schwannoma underwent an assessment of static SVV under the conditions with both eyes open and afterwards with each eye covered with an eye patch in turn. Subjects were seated in a chair in a completely dark square room where no visual clues were present, and their head and chin were fixed on a forehead-chin rest in an upright position. A luminous straight bar (length 80 millimeters (mm), width 10 mm) was back-projected on a large black screen 50 centimeters (cm) in front of the examinee, who could freely rotate the bar with a joystick, and once the bar was tilted, they were instructed to use the joystick to bring the bar back to a vertical position. The true vertical orientation was set as 0 degree, and the initial tilt of the bar was randomized before each trial. Final tilts of the bar determined by the examinee were indicated as angles, and leftward and rightward tilts were represented by negative and positive angles, respectively. Tilts of SVV were measured 6 successive times for each patient, and then averaged. According to our previous study of SVV tilts in 51 healthy subjects ( $0.22 \pm 1.26$  degrees of mean  $\pm$  standard deviation), normal range of the SVV tilt was defined as ranging from  $- 2.30$  to

+ 2.74 degrees (10). In the patients with vestibular schwannoma, tilts toward the ipsilesional and contralesional sides were defined as positive and negative values, respectively. The times spent for the measurements of all the monocular and binocular SVV in this study was also recorded and compared.

## Results

### Vestibular function test

None of the 20 controls showed CP, however all 31 patients with vestibular schwannoma did. No abnormal eye movement that had the brainstem and/or cerebellum as an origin was observed. In the 31 patients with vestibular schwannoma, VOR-gains were normal on the healthy side.

### SVV

#### Controls

Mean values of monocular SVV measurements of the right and left eyes were  $0.5 \pm 1.9$  degrees (hereafter mean  $\pm$  2S.D.) and  $-0.1 \pm 1.5$  degrees, respectively, and that of binocular measurements were  $0.4 \pm 1.9$  degrees. All of measurements of right eye, those of left eye, and those of both eyes were within normal range (Figure 1.).

## Patients with vestibular schwannoma

Of the 31 patients, 19 patients (61.3%) showed abnormal tilts of SVV in binocular measurements. Of these 19 patients, 11 (57.9 %) were postoperative. In the remaining 12 patients showing no abnormal tilts of SVV, mean value of monocular measurements of the affected-side and normal-side eyes were  $1.0 \pm 1.3$  degrees and  $0.7 \pm 2.1$  degrees, respectively, and that of binocular measurement was  $0.5 \pm 1.1$  degrees. There were no significant differences among the three measurements (Mann-Whitney's U-test, Figure 2). In the 19 patients showing abnormal tilts of SVV in binocular measurements, the mean value of monocular measurements with the affected-side, normal-side and both eyes were  $5.7 \pm 9.1$  degrees  $5.6 \pm 11.0$  degrees and  $5.1 \pm 8.7$  degrees, respectively. There were no significant differences among the three measurements (Mann-Whitney's U-test, Figure 3).

The time required for all the binocular measurements was within 5 minutes, while all binocular and each monocular measurements took about 15 minutes. There were no significant differences between the degrees of SVV tilts and CP%.

## Discussions

In the SVV test, subjects have to set a luminous bar to a vertical position while



seated upright in a darkened room. To accurately orient the luminous line, subjects must completely compensate for any changes in eye position such as torsional eye movements. In the present study, all values of SVV measured by monocular and binocular eyes in normal subjects were within the normal range defined by our previous study using normal controls (10). In humans, gravitational information is stored in the vestibular system and internal estimation to gravitational movement is constructed. SVV is assumed to be based on the internal estimation of verticality by the vestibular network (11, 12). Thus, we were expecting that there would be no difference in verticality perception between monocular and binocular visions with normal subjects who have no abnormal eye position nor mismatch between visual and vestibular signals.

In the 31 patients with vestibular schwannoma, caloric response was performed to evaluate vestibular function. Caloric test is assumed to be a test for evaluating the horizontal canal mainly. However, CP in vestibular schwannoma that has not extended to the brainstem is assumed to mean dysfunction of the superior vestibular nerve including signals from the utricle. Thus, CP is chosen as the criterion of vestibular dysfunction in the present study. Indeed, it is known that the patients with vestibular dysfunction such as vestibular neuritis or vestibular schwannoma often show long lasting abnormal tilts of SVV that is associated with CP (2, 13, 14). In the 31 patients

with vestibular schwannoma, all had imbalance of vestibular signals showing CP in caloric tests, demonstrated no significant difference of SVV values between monocular and binocular measurements. Binocular vision enables to measure a distance of the subject by perceiving the distance to the subject with stereopsis ( 15,16 ) . However, since alternation of a position of a subject on the coronal plane, such as the measurement of SVV, does not cause any change in the distance from the eyes to the subject, recognition of the alternation of the angle of the subject on the coronal plane tilt may not be affected by monocular or binocular vision.

Thus, the present results suggest that binocular measurements can detect abnormality in patients with vestibular dysfunction with the same sensitivity as monocular measurements. A benefit of the SVV test is its simplicity and that requires little time. All the binocular measurements were taken within 5 minutes, while the binocular and each monocular measurement took about 15 minutes, respectively.

In the present study, binocular and monocular measurements did not show any significant difference in the sensitivity of the detection of abnormalities of SVV in patients with vestibular schwannoma. That is to say, our results suggest that binocular measurements of SVV test can detect abnormality in patients with vestibular schwannoma with the same sensitivity as monocular measurements.

Although monocular measurements are required for research purposes or in a monocular lesion such as trochlear nerve palsy, a physician may be able to omit monocular measurements in a routine vestibular test for detecting abnormal tilts of SVV in patients with vestibular dysfunction and save about one third of the time needed for the test. This may be useful time saver for a routine vestibular test required for the SVV test.

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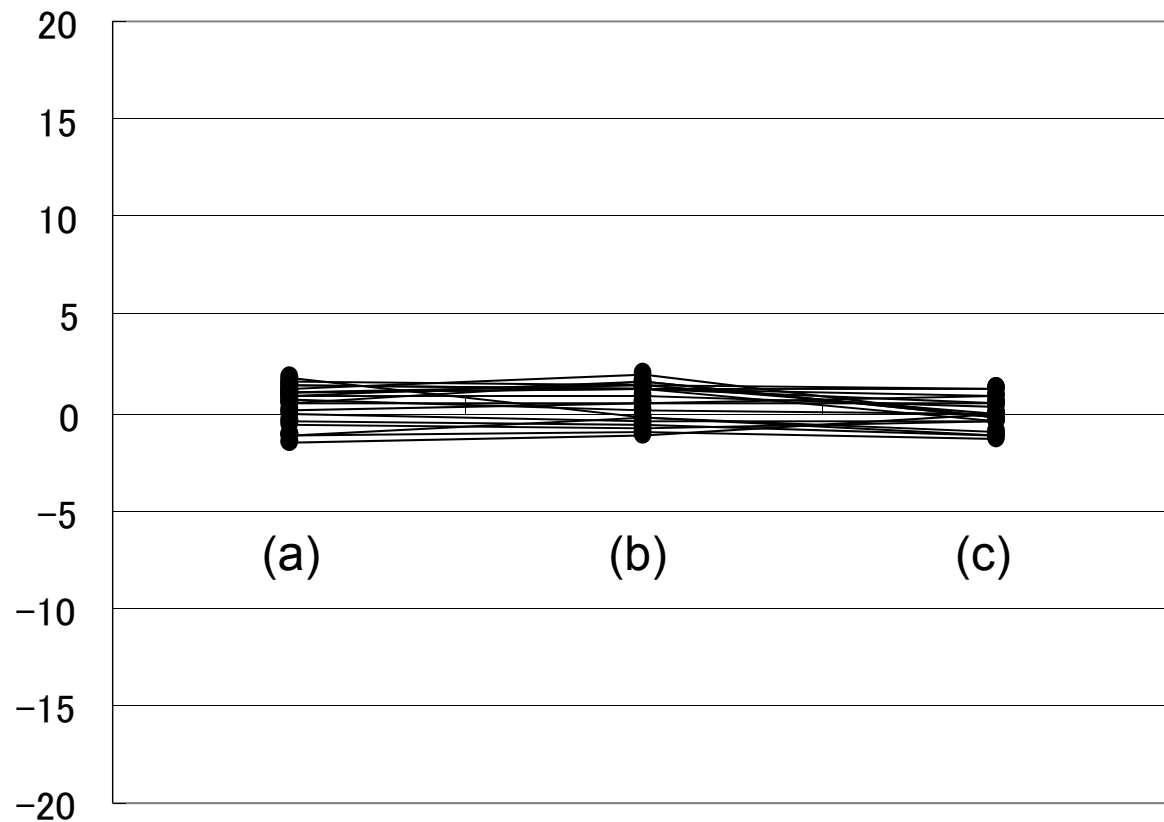


Figure 1. SVV in the controls (N=20)

(a) Monocular measurements with the right eye , (b) Monocular measurements with the left eye, (c) Binocular Measurements with the both eyes.

All of measurements of right eye, those of left eye, and those of both eyes were within normal range.

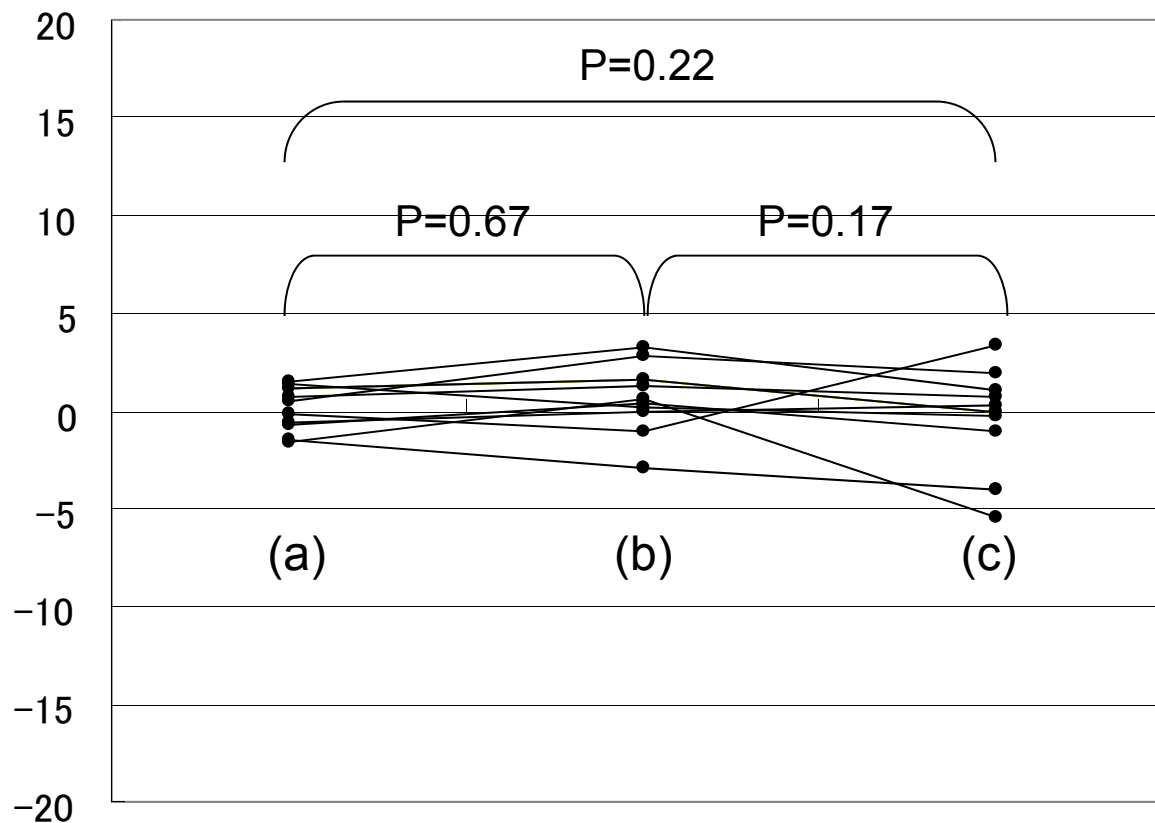


Figure 2. Results of monocular and binocular measurements in patients with vestibular schwannoma showing normal tilts of SVV (mean  $\pm$ 2SD, N=12) (a) Measurements with the affected-side eye ( $1.0 \pm 1.3^\circ$ ), (b) Measurements with the normal-side eye ( $0.7 \pm 2.1^\circ$ ), (c) Measurement with the both eyes ( $0.5 \pm 1.1^\circ$ ). There were no significant differences between monocular and binocular measurements (Mann-Whitney's U-test).



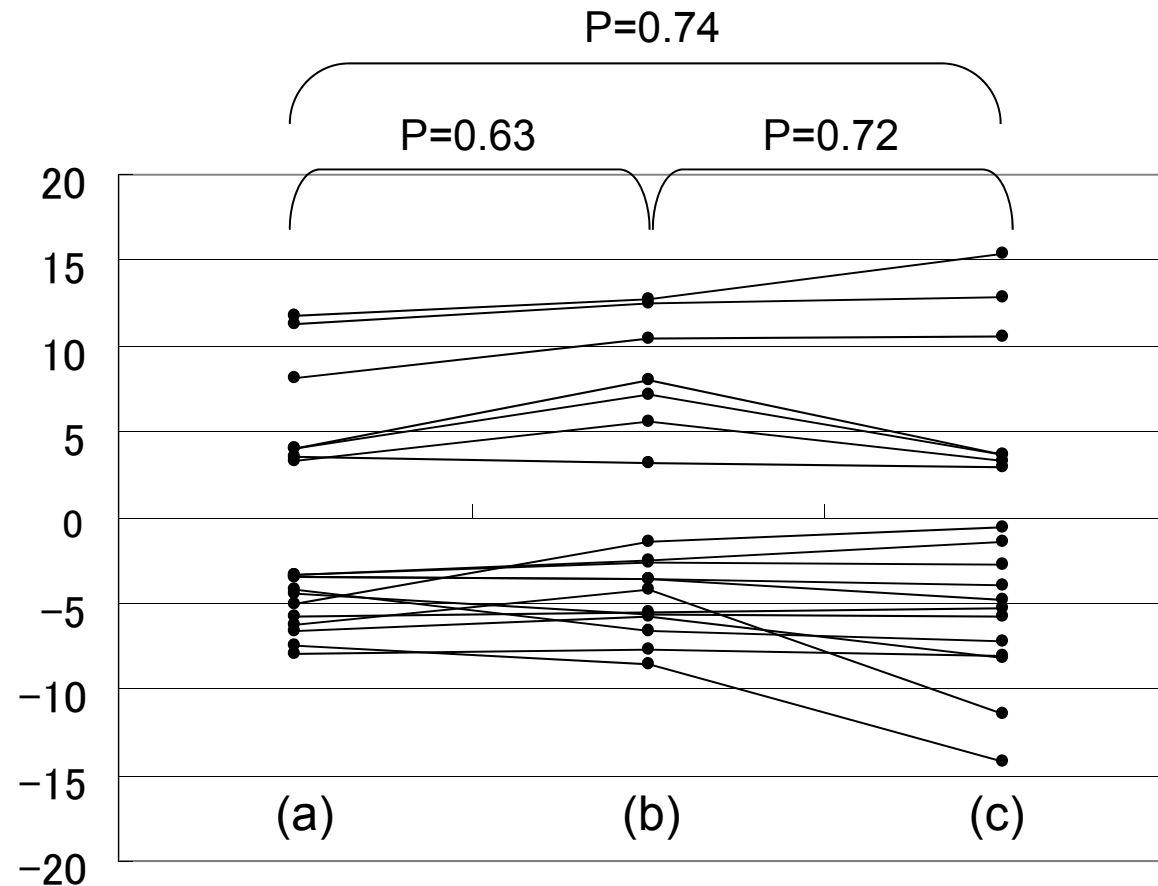


Figure 3. Results of monocular and binocular measurements in patients with vestibular schwannoma showing abnormal tilts of SVV (mean  $\pm 2SD$ , N=19). (a) Measurements with the affected-side eye ( $5.7 \pm 9.1^\circ$ ), (b) Measurements with the normal-side eye ( $5.6 \pm 11.0^\circ$ ), (c) Measurement with the both eyes ( $5.1 \pm 8.7^\circ$ ). There were no significant differences between monocular and binocular measurements (Mann-Whitney's U-test).