—**Original**—

A Comparative Study on the Observation of Spontaneous Nystagmus with Frenzel Glasses and an Infrared CCD Camera

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Abstract

Objectives: To compare the usefulness of a CCD camera with infrared illumination (IR-CCD camera) over Frenzel glasses (F Glasses) for the observation of spontaneous nystagmus, the incidence and direction of nystagmus, and the frequency, amplitude and slow phase of spontaneous nystagmus.

Methods: One hundred vertiginous patients, fifty-three females and forty-seven males participated in this study. Before undergoing routine neurotological examination, their eye movements were recorded by electronystagmogram (ENG) in conjunction with observations of eye movements under F glasses and through an IR-CCD camera. The data was collected from patients who exhibited spontaneous nystagmus either under F glasses or the IR-CCD camera.

Results: Thirty-three patients showed spontaneous nystagmus under F glasses. On the other hand, under the IR-CCD camera, all patients examined exhibited spontaneous nystagmus. The frequency of nystagmus was not significantly different between these two systems. However, the amplitude and slow phase velocity exhibited significantly larger values under the IR-CCD camera in patients with spontaneous nystagmus both under the IR-CCD camera and F glasses.

Conclusion: From these observations and evidence, the IR-CCD camera can be recommended as a more useful system and powerful tool for neurotological examination than F glasses.
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Key words: video, slow phase velocity, frequency, amplitude, routine examination

Introduction

The observation of eye movements, especially nystagmus is essential for evaluating the pathologies of both the peripheral and central vestibular system. It is well known that visual inputs or eye fixation suppress the vestibular-evoked nystagmus. Therefore, the observation of eye movements in complete darkness is a crucial and integral part of the examination of the vestibular system. F glasses are routinely used in clinical examinations for spontaneous and/or evoked nystagmus. However, we cannot suppress the visual input completely using F glasses. Nowadays, in routine neurotological examinations the IR-CCD camera is being more widely used for observ-

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Table 1 Etiology of vertigo in all subjects

Etiology	Number of Patients
Peripheral lesion	20
Benign paroxysmal positional vertigo	13
Sudden Deafness	9
Meniere's disease	8
Bell's palsy	6
Otitis media	4
Delayed endolymphatic hydrops	4
Central lesion	4
Hunt's syndrome	3
Perilymph fistula	2
Vestibular neuritis	2
Acoustic tumor	1
Sensory neural hearing loss	1
Unknown	23
Total	100

ing nystagmus through a TV monitor. IR-CCD camera permits us to observe the eye movements in total darkness. In this study, we have compared the incidence and direction of nystagmus, and the frequency, amplitude and slow phase of spontaneous nystagmus recorded by ENG, using two systems, namely F glasses and the IR-CCD camera.

Materials and Methods

One hundred vertiginous patients, fifty-three females and forty-seven males ranging in age from 12 to 85 years participated in this study. The mean and standard deviation of age was 54.4 ± 16.4 (mean ± standard deviation; same in the text and tables), respectively. All subjects had given informed consent according to the Helsinki Declaration to participate in this study. Before undergoing routine neurotological examination, their eye movements were recorded by ENG in conjunction with observations of eye movements under F glasses (Nagashima Medical Instrument, Tokyo) and through IR-CCD (IEM-2, Nagashima Medical Instrument, Tokyo) camera. The patients were kept in a supine position. The order of observation whether under F glasses or the IR-CCD camera was decided at random. The data in this study was collected from patients who exhibited spontaneous nystagmus either under F glasses or the IR-CCD camera. The etiology of vertigo is demonstrated in **Table 1**. The data analyzed in this study consist of the incidence of detection, direction, frequency, amplitude, and slow phase velocity of nystagmus. Statistical analysis was performed using t-test (paired and unpaired). The significant threshold was set at $p = 0.05/6$ with Bonferoni correction.

Results

1. Incidence of Detection

Thirty-three patients showed spontaneous nystagmus under F glasses. On the other hand, under the IR-CCD camera, all patients examined exhibited spontaneous nystagmus. In other words, the IR-CCD camera has about three times greater sensitivity than F glasses for detecting spontaneous nystagmus.

2. Direction of Nystagmus

Horizontal nystagmus was detected in 30 patients (91%) under F glasses and in 90 patients (90%) under the IR-CCD camera. Under F glasses, right and left directed nystagmus was identified in 18 and 12 patients, respectively. Under the IR-CCD camera, right and left directed nystagmus was detected in 48 and 42 patients, respectively. Up beating nystagmus was identified under F glasses and IR-CCD camera in 3 (9%) and 10 (10%) patients, respectively. On the other hand, no subjects showed down beating nystagmus. The direction of nystagmus identified under F glasses was comparable to the direction of nystagmus detected with the IR-CCD camera.

3. Frequency of Nystagmus

The average frequencies during a period of 10 seconds in patients who showed nystagmus both under F glasses and the IR-CCD camera ($n = 33$) were 0.83 ± 0.43 beats/sec and 1.06 ± 0.43 beats/sec, respectively. There was no significant difference between these two values (**Table 2**). The average frequency of nystagmus revealed by the IR-CCD camera when no nystagmus was found under F glasses ($n = 67$) was 0.92 ± 0.51 beats/sec. This value was not significantly different from the value found with F glasses, either (**Table 3**).

Table 2 Frequency, amplitude, and slow phase velocity in patients with nystagmus both under F glasses and IR-CCD camera (paired t-test)

	Frequency (beats/sec)	Amplitude (deg)	Slow phase velocity (deg/sec)
F glasses	0.83 ± 0.43	1.89 ± 1.17	2.68 ± 1.84
	NS	$p < 0.001$ (SN)	$p < 0.001$ (SN)
IR-CCD camera	1.06 ± 0.43	3.02 ± 1.51	4.82 ± 3.20

(SN: significant, NS: not significant)

Table 3 Frequency, amplitude, and slow phase velocity of spontaneous nystagmus under IR-CCD camera in patients with or without nystagmus under F glasses (unpaired t-test)

Nystagmus	No. of patients	Frequency (beats/sec)	Amplitude (deg)	Slow phase velocity (deg/sec)
No	67	0.92 ± 0.51	2.17 ± 1.44	3.05 ± 2.86
		NS	$p = 0.0076$ (SN)	$p = 0.006$ (SN)
Yes	33	1.06 ± 0.43	3.02 ± 1.51	4.82 ± 3.20

(SN: significant, NS: not significant)

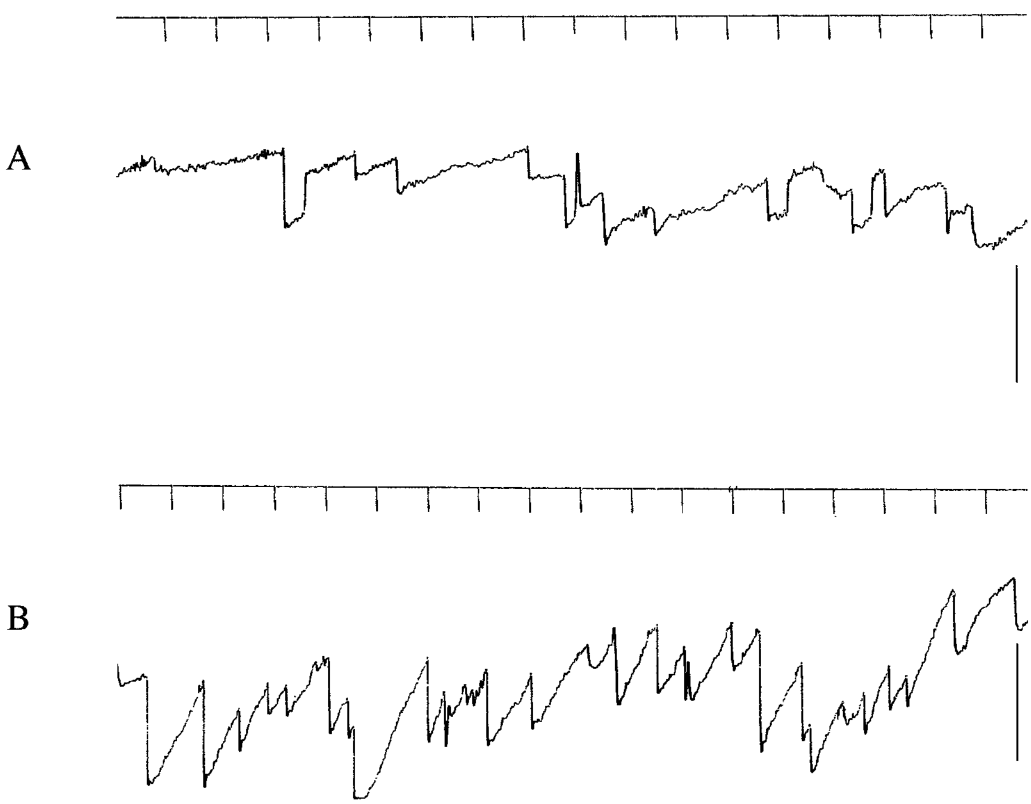

Fig. 1 ENG recording of a subject who exhibited spontaneous nystagmus both under F glasses (A) and IR-CCD camera (B).
The upper traces in A and B indicate the one-second time marker. The vertical bars show the amplitude of 10 degrees eye movement.

4. Amplitude of Nystagmus

The average amplitudes of spontaneous nystagmus in patients who exhibited nystagmus both under F glasses and the IR-CCD camera were 1.89 ± 1.17 deg and 3.02 ± 1.51 deg, respectively. The amplitude of nystagmus under IR-CCD camera was significantly larger than that observed under F glasses (**Table 2**). The average amplitude of nystagmus revealed by the IR-CCD camera in those without nystagmus according to F glasses was 2.19 ± 1.44 deg. Th is value was significantly smaller than that in cases with nystagmus revealed by F glasses (**Table 3**).

5. Slow Phase Velocity of Nystagmus

The average slow phase velocity of nystagmus in those who showed nystagmus both under F glasses and the IR-CCD camera was 2.68 ± 1.84 deg/sec and 4.82 ± 3.20 deg/sec, respectively. The slow phase velocity of nystagmus shown by the IR-CCD camera was clearly faster than that shown by F glasses (**Table 2**). The slow phase velocity revealed by the IR-CCD camera in those without nystagmus under F glasses was 3.05 ± 2.86 deg/sec. This velocity was significantly slower than that identified in patients who showed nystagmus under F glasses (**Table 3**). **Fig. 1** shows an example of ENG in a subject who exhibited spontaneous nystagmus both under F glasses and the IR-CCD camera. In this particular case, the average slow phase of nystagmus under F glasses and the IR-CCD camera was 1.3 deg/sec and 7.5 deg/sec, respectively.

Discussion

It is well known that visual inputs strongly suppress the vestibular evoked eye movements[1,2]. The central nervous system, especially the vestibular cerebellum, plays a major role in this physiological phenomenon[3,4]. Therefore, the visual suppression or fixation suppression has been used in clinical examination to detect the pathology of the brainstem and/or cerebellum[5,6].

Baloh et al.[7] demonstrated the influence of visual information upon caloric nystagmus using ENG. They found the maximum slow phase velocity of the caloric nystagmus decreased to about one tenth, 30.8 ± 12.3 deg/sec to 3.2 ± 3.1 deg/sec, when the subjects fixed their eyes on a small dot as compared to when their eyes were kept open in complete darkness. In addition, they found that the maximum slow phase velocity of the same nystagmus under F glasses was 15.8 ± 5.6 deg/sec. In the present study, we found that the slow phase of spontaneous nystagmus under F glasses was clearly slower (2.68 ± 1.84 deg/sec) than that under IR-CCD camera (4.28 ± 3.20 deg/sec) in the same patients. Thus, the ratio of the slow phase velocity of nystagmus under F glasses to that under IR-CCD camera or total darkness was quite similar in both studies.

Frenzel[8] used specially designed goggles, now called Frenzel glasses, which consist of 20 diopter concave lenses with small lights inside. Using the glasses, the examiner can see a magnified image of the patients' eyes. In addition, patients cannot fix their eyes on objects outside of the goggles (because of the effects of concave lenses). Frenzel did not know about the relation of this suppression phenomenon and the physiological mechanism of the central nervous system when he developed this glass "Leuchtbrille". From then on, these glasses have been widely used to observe nystagmus in daily clinical practice for reducing the fixation suppression.

Nowadays, the IR-CCD is being used extensively to record human eye movements for the purpose of three-dimensional analysis (horizontal, vertical and torsional) by computer, since the ENG can record only two dimensional eye movements, horizontal and vertical. The IR-CCD camera permits us to record clear images of the eyes, from which gray scale histograms of the eyes, pupil and iris striations, can be created easily. In addition, the computer is able to analyze the eye movements three-dimensionally[9–11]. The IR-CCD camera has become widely used in the neurotological clinics for daily examination especially in Japan, because of the clarity it permits in observations of the images of the eyes and its ability to examine eye movements in total darkness. Furthermore, the observations can be recorded on to videotape. The ENG can also record eye movements in total darkness, but you cannot observe the subjects' eyes directly. The observation of eye movements on a TV monitor through the IR-CCD camera is also very useful in educating junior doctors, medical students, co-medical staff including nurses, and even the patient himself and/or his relatives. From these observations and evidence, we recommend that the IR-CCD camera should be used more world wide as a powerful tool for neurotological examinations instead of the F glasses.

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