



NOTE

Surgery

Measurement of visual acuity in Beagle dog by visual evoked potential with pattern stimulation

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ABSTRACT. We tried measurement of visual acuity in laboratory beagle using pattern stimulus visual evoked potential (P-VEP). We recorded P-VEP in 6 beagles which were corrected refractive power. The stimulus pattern size was 1.22 mm. The testing distance were 0.5, 1.0, and 2.0 m. The visual angles and spatial frequency were calculated from stimulus pattern size and distance. In all subjects, P-VEP was clearly recorded in all testing distance, and this result means that the eye could recognize grid pattern on the stimulus monitor. When stimulus monitor was set up 2.0 m, spatial frequency was 14.29 cpd. From our results, it was founded that the visual acuity in laboratory beagle which was corrected refractive power was 14.29 cpd and more.

KEY WORDS: canine, visual acuity, visual evoked potential with pattern stimulation

Visual acuity is ability of identify two separate points or lines, and represented by visual angle or spatial frequency [6]. Visual angle is the angle between two points and the eye, and the units is minute. Spatial frequency is the number of light and dark construction in 1 min of visual angle, and the unit is cycle per degree (cpd). The smaller visual angle indicate higher visual acuity, and bigger spatial frequency indicate higher visual acuity.

The most important purpose of human clinical ophthalmology is that improves or maintains visual acuity of patient. For that reason, visual acuity test is routine examination in human clinical ophthalmology. However, these visual acuity test is subjective examination, so cannot apply for clinical veterinary ophthalmology. In clinical veterinary ophthalmology, menace response, maze test, or cotton ball test are performed that are objective examination, and are evaluated only positive or negative for vision.

The visual evoked potential (VEP) test is one of the examination that can evaluate visual acuity objectively. The VEP test is a method for detecting brain wave signals from the visual cortex induced by a light stimulus [2, 4]. The VEP is classified into flash-stimulated VEP (F-VEP), which uses a flash stimulus and pattern-stimulated VEP (P-VEP), which uses a contrast-reversing checkerboard pattern stimulus. In our previous study, we reported about measurement of visual acuity by P-VEP, and we showed visual acuity of beagle was 0.54–2.14 cpd and more by our method [4]. On the other hand, Odom *et al.* have reported that canine visual acuity was 12.59 cpd [8]. In this study, we tried measuring more detail visual acuity of beagles using our P-VEP method.

Six eyes of 6 normal laboratory-beagle dogs were used in this study. The beagles were 6 years old, and the body weights were 10 to 16 kg. This study was approved at No. VH24B3, and was conducted according to the guidelines of experimental animal research committee of Rakuno Gakuen University.

The refractive power of the recorded eyes was measured by skiascopy according to the previous method reported by Maehara *et al.* [5]. The refractive power was measured with a streak retinoscope (Streak Retinoscope RX-3A, Neits Instruments Co., Ltd., Tokyo, Japan) and a skiascopic lens (Hatake Skiascope, Handaya Co., Ltd., Tokyo, Japan) under dim light 60 min after applying cyclopentolate hydrochloride eye drops (Cyplegin 1%, Santen Pharmaceutical Co., Ltd., Osaka, Japan) as a cycloplegic drug.

For P-VEP recording, needle electrodes (VEP needle electrodes, Mayo Corp., Nagoya, Japan) were positioned at theinion (external occipital pro-tuberance) as the recording electrode and the nasion (nasal point) as the reference electrode. A plate-type electrode (LE ear electrode, Mayo Corp.) was positioned on the inner surface of the right auricle as an earth electrode, as in previous reports [2–4] (Fig. 1). A portable ERG/VEP system (LE-3000, TOMEY, Nagoya, Japan) and pattern stimulus display (PS-410, TOMEY) were used for the study. The details of this display were as follows: indicated color, yellow (580 nm);

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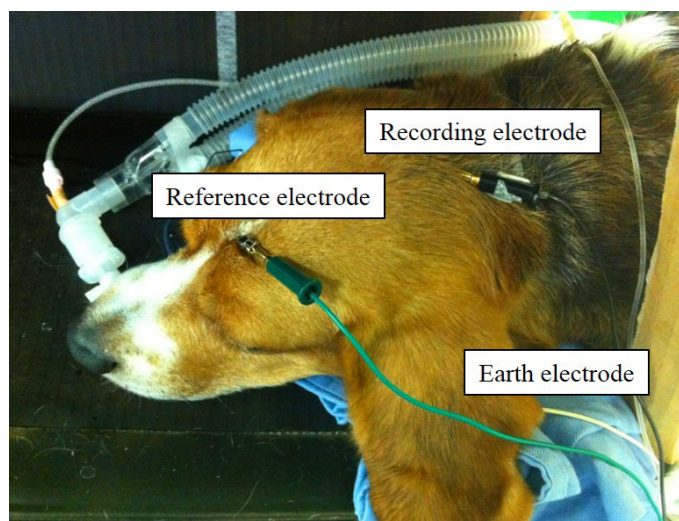


Fig. 1. Electrode positions for recording P-VEP.

Table 1. Visual angle and spatial frequency in each testing distance

Testing distance (m)	Visual angle (min of arc)	Spatial frequency (cpd)
0.5	8.39	3.58
1.0	4.20	7.14
2.0	2.09	14.29

resolution, 640 × 400 dots; indicated area, 122 × 195 mm; pixel size, 0.22 × 0.22 mm; frame frequency, 60 Hz; contrast, 75%; and mean luminosity, 15 cd/m². P-VEP were recorded under sevoflurane in oxygen anesthesia using a mask and intubated with an endotracheal tube. While recording P-VEP, the position of the eye was fixed by administration of rocuronium bromide (Eslax, MSD, Tokyo, Japan). Continuous intravenous infusion of rocuronium bromide was performed at 0.2 to 2.0 mg/kg/hr from a catheter placed in the saphenous vein using a syringe pump. The testing distance which was the distance from the cornea to display were 0.5, 1.0, and 2.0 m. The stimulus pattern size was 1.22 mm. The refractive power of the recorded eyes were corrected to -2, -1, and -0.5 diopters in 0.5, 1.0, and 2.0 m testing distance, respectively, using soft contact lenses (Premio, Menicon, Nagoya, Japan) based on obtained skiascopy. The stimulation rate was 3 reversals/sec. The P-VEP signal was averaged from 128 repetitions.

We calculated visual angles and spatial frequency based on previous study [1]. At first, visual angles were calculated by formula (1), after that spatial frequency were by formula (2). Formula (1); visual angle (min of arc)=(3,440/1.22)/ (stimulus distance), Formula (2); spatial frequency (cpd)=30 / (visual angle). P100 implicit time and N75-P100 amplitude were estimated according to a standard determined by the ISCEV [7]. The P100 implicit time and N75-P100 amplitude recorded each testing distance were compared using one-way factorial ANOVA analysis with Tukey's multiple comparisons test. The statistical significance of differences was determined with $P < 0.05$ as the minimum level of acceptable significance. Statistical methods were computed using GraphPad Prism 7 software (GraphPad Software Inc., La Jolla, CA, U.S.A.) for Windows.

The visual angle and spatial frequency in each testing distance were shown in Table 1. The visual angle and spatial frequency were 8.39 min of arc and 3.58 cpd in 0.5 m testing distance, 4.20 and 7.14 in 1.0 m, and 2.09 and 14.29 in 2.0 m, respectively.

The VEP waveforms recorded each dogs were shown in Fig. 2. In all subject's eyes, VEP was clearly recorded in all stimulus distance, and P100 waves appeared almost 100 msec after stimulus. The average value of implicit time of P100 was 99.9 ± 14.6 msec in 0.5 m testing distance, 112.3 ± 18.5 msec in 1.0 m, and 115.3 ± 16.4 msec in 2.0 m. The implicit time of P100 in testing distance 1.0 and 2.0 m were significantly prolonged compared with that of 0.5 m (Fig. 3). The average value of amplitude of N75-P100 was 2.20 ± 1.16 μV in 0.5 m testing distance, 2.71 ± 1.26 μV in 1.0 m, and 2.57 ± 1.20 μV in 2.0 m. There were no significant difference in the amplitude of N75-P100 among in testing distance 0.5, 1.0, and 2.0 m (Fig. 4).

In present study, we recorded P-VEP in laboratory beagle which was corrected refractive power, and calculated visual angle and spatial frequency from testing distance and stimulus pattern size, tried measurement of visual acuity. When stimulus monitor was set up 2.0 m front of eyes, and stimulus pattern size was set up 1.22 mm, P-VEP was clearly recorded in all subject's eyes. The result that P-VEP was clearly recorded means that the eyes could recognized grid pattern reflected on the stimulus monitor. When stimulus monitor was set up 2.0 m front of eyes and pattern size was set up 1.22 mm, spatial frequency was 14.29 cpd. From our results, it was founded that the visual acuity in laboratory beagle which was corrected refractive power was 14.29 cpd and more.

Odom *et al.* have reported that canine visual acuity was 12.59 cpd [8]. In this previous study, visual acuity was measured by VEP same as our study. In Japan, visual acuity is generally expressed by decimal visual acuity. The decimal visual acuity is expressed in reciprocal number of minimal visual angle, so 12.59 cpd and 14.29 cpd is about 0.4 and 0.5 converting to decimal visual acuity, respectively. From our results, it was shown that dog has slightly superior visual acuity than previous reports. In our method, it was thought that further visual acuity measurement becomes possible if the stimulus distance is made long. Since dogs may possess superior eyesight, it seemed that further visual acuity evaluation should be done in the future research.

In this study, implicit time of P100 in testing distance 1.0 and 2.0 m were significantly prolonged compared to that of 0.5 m. As the distance to the stimulus monitor increases, the visual angle decreases. The smaller the visual angle, for recognizing to object, the higher visual acuity is required. It was thought that the prolongation of P100 implicit time in testing distance 1.0 and 2.0 m were due to decrease of visual recognition. But, the P100 in testing distance 1.0 and 2.0 m were appeared about 100 msec after

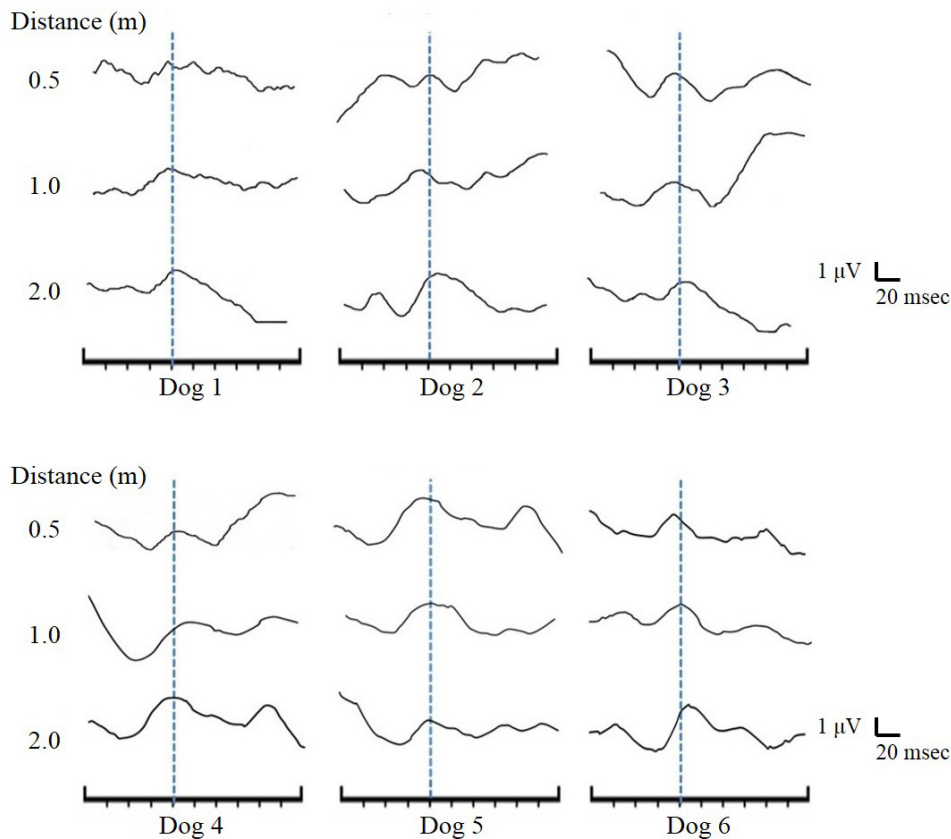


Fig. 2. P-VEP waveforms obtained from six dogs at each recording distance. The dot line showed 100 msec after stimulation.

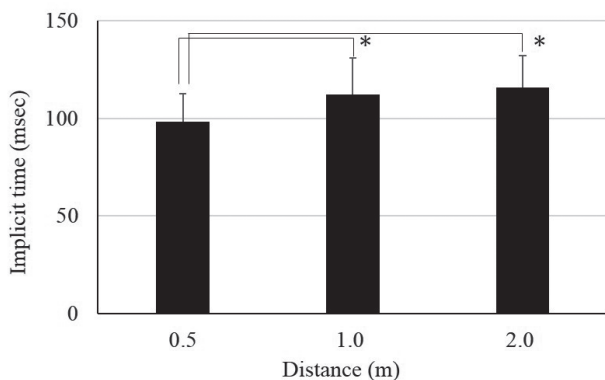


Fig. 3. The P100 implicit time at each recording distance. The graphs show the means and error bars show the standard deviation. Significant differences compared with 0.5 m are shown by asterisks.

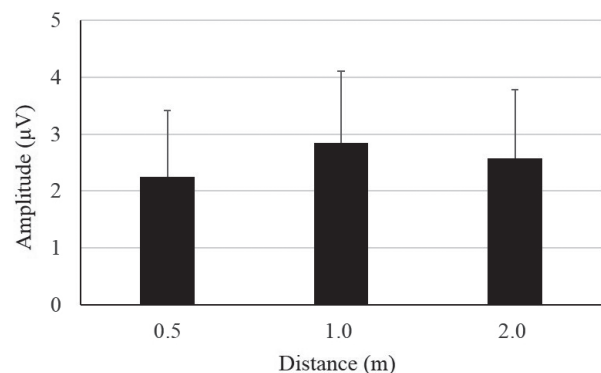


Fig. 4. The N75-P100 amplitude at each recording distance. The graphs show the means and error bars show the standard deviation.

stimulation, we thought that the dog recognized grid pattern in stimulus monitor.

We had reported about visual acuity in normal beagle, and we showed visual acuity of beagle was 0.54–2.14 cpd [4]. Since we had not considered the refractive power of the eye in previous study, so we thought that the results differ from present study. After that, we reported that refractive power of the subject’s eye affects P-VEP wave form [3], so we recorded P-VEP after correction of refractive power of subject’s eye in this study. Refraction in an eye is the change in direction of light when light passes from the optic media toward the retina [6]. The refractive power indicates the degree of the defocusing of light on the retina. In previous study, it was reported that the P100 appeared at almost 100 msec as corrected refractive power to stimulus distance, while significant prolongation of the P100 implicit time was detected when the refractive power was defocusing to stimulus monitor [3]. In present study, P-VEP was recorded the eyes correcting refractive power, so we were able to measure the visual acuity of a dog

not affected by refraction.

Currently, in clinical veterinary ophthalmology, various treatments for visual acuity improvement have been carried out for various ocular diseases such as cataract and glaucoma. However, it is generally that only the positive or negative of vision has been evaluated in patients. It was thought that if evaluation of visual acuity becomes possible, the therapeutic effect becomes obvious, and the owner seems to be easy to understand the treatment, so it seemed important to show the visual acuity of normal dog in this study. However, all subjects in this study were 6 years old beagles. In future study it is necessary to examine differences in visual acuity depending on breed and age.

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