Pattern and Sweep Visual Evoked Potential in the Objective Determination of Visual Acuity

Mualla Hamurcu, MD (hamurcu2003@yahoo.com)
Ankara Numune Training and Research Hospital, Department of Ophthalmology

Research Article

Keywords:

Posted Date: December 5th, 2018

DOI: https://doi.org/10.21203/rs.2.57/v1

Abstract

Background: To investigate the effects of pattern visual evoked potential (pVEP) and sweep visual evoked potential (sVEP) on the accurate visual acuity (VA) measurement in adults.

Methods: Medical files of 282 eyes of 141 patients who underwent VA measurement in our electrophysiology laboratory and did not undergo simulation were retrospectively analyzed. The VA was measured using the Snellen chart. Only those with a VA of higher than 1/10 on the Snellen chart were included in the study. The VA was assessed and reported by the pVEP (VA-pVEP) and sVEP test (VA-sVEP). The correlation analysis was performed using the Pearson correlation analysis.

Results: Of 141 patients, 92 were males and 49 were females with a mean age of 37.7±18.4 years. There was a strong positive correlation between the VA values obtained from both eyes by pVEP (VA-pVEP) ($r=0.858$, $p<0.001$). There was a weak positive correlation ($r=0.267$, $p<0.001$) between the VA measured by the Snellen chart and the VA measured by the sVEP (VA-sVEP). A weak positive correlation was found for the VA-pVEP and VA-sVEP ($r=0.313$, $p<0.001$).

Conclusions: For the measurement of the degree of the VA, it seems reasonable to use pVEP initially, while sVEP should be used in cases with short attention span and those who are non-cooperative and in infants.

Background

The visual acuity (VA) is one of the most important measurement in the assessment of the sensorial visual development and function in human. Until now, a number of tests for the measurement of VA have been developed. In the ophthalmology practice, electrophysiological tests can be used to measure the VA in infants, in non-cooperative cases, and in cases where the refraction is unable to be assessed due to media opacity and in the functional visual loss [1-9]. In addition, electrophysiological tests are the main tools of objective measurement of the vision in medico-legal conditions for clinicians [10].

Three stimuli have been identified for visual evoked potentials (VEP) by the standards established by the International Society for Clinical Electrophysiology of Vision (ISCEV), and the VEP test has been standardized with pattern (reversal or onset/offset) and flash stimuli [6,7]. Flash (fVEP), pattern (pVEP), and sweep visual evoked potentials (sVEP) are the tests for objective determination of the visual function in the clinical practice. The vision can be tested by the fVEP, while the VA is measured according to the response to the pattern shown in varying sizes by the pVEP. Also, the sVEP test, which can be only used in the laboratory setting in accordance with the ISCEV VEP 2016 standards, is a VEP type and is used for rapid evaluation of the visual function.

In our electrophysiology laboratory, the pVEP and sVEP are routinely performed in the objective measurement of the VA. In the literature, there is a number of studies investigating the pVEP and sVEP in infants. However, in the present study, we aimed to investigate the effects of pVEP and sVEP on the accurate VA measurement in adult patients.

Methods

This retrospective study included a total of 282 eyes of 141 patients who underwent VA measurement in the Electrophysiology Laboratory of Ankara Numune Training and Research Hospital, Eye Clinic and did not undergo simulation between February 2014 and May 2017. The examination and test results were obtained from the patient files. The VA was measured by the Snellen chart. Patients with a VA of less than 1/10 on the Snellen chart were excluded from the study. Patients with refractive errors of spherical equivalents ≤ +/- 3.0, cylindrical equivalents ≤ +/- 2.0 were included in the study. Best corrected VA recorded. pVEP and sVEP tests were performed with corrected glasses. The VA was assessed and reported by the pVEP (VA-pVEP) and sVEP test (VA-sVEP). The study was approved by the institutional Ethics Committee. A written informed consent was obtained from each patient. The study was conducted in accordance with the principles of the Declaration of Helsinki.

In our clinic, the VEP records are collected using the Metrovision-Vison Monitor™ system in accordance with the standards recommended by the ISCEV. The pVEP test is routinely used in the objective measurement of the VA. In pVEP, different pattern sizes are used (120', 60', 30', 15', 7') in the checkerboard pattern and the amplitudes and latencies of the P100 response are evaluated. The pattern sizes are determined based on the angle of each pattern with the fovea when the patient is looking at the screen. A clock dial is 1 degree (1°) and one in 60 of the each clock dial is one minute (1'). If the vision pathology is in one eye, the values of the other eye are used as the reference values; however, in suspected patients with bilateral pathology, P100 values obtained from the age-matched normal population, which are defined in our laboratory in accordance with the ISCEV standards, are used. The VA is reported according to the response in the smallest pattern by examining the morphology and amplitude values of the aforementioned pattern sizes.

In the sVEP, VEP is recorded with a checkerboard-pattern stimulus which alternates at a frequency ranging from 5 to 15 Hz and in which the pattern sizes lessen within 10 seconds, where the mean brightness is 50 cd/m2 and in which the case is seated 2 m away from the monitor. During recording, the patient is asked to look at the fixation point, which is in the form of a red square, in the center of the monitor. The patients are examined with the VEP test with a VA value of 0.03 to >1.1 and 10 sVEP records which last 10 seconds are obtained. The stimulus is initially displayed at low spatial frequency, and the steady-state response is achieved. Then, the spatial frequency is gradually increased to the upper limit. The VA of 1.0 on the Snellen chart is equal to the angle of 1 arcmin, which is equal to 30 cycle/degree. The mean and maximum VA of the right and left eye are recorded with the sVEP in each case.

Statistical analysis was performed using the SPSS version 22.0 software (IBM Corp., Armonk, NY, USA). Descriptive data were expressed in mean ± standard deviation (SD) and median (min-max) values for categorical variables and in number and frequency (%) for numerical variables. The correlation analysis was performed using the Pearson correlation analysis. A *p* value of 0.05 was considered statistically significant.

Results

Of 141 patients, 92 (65.2%) were males and 49 (34.8%) were females. The mean age was 37.7±18.4 (range: 13 to 84) years.

There was a strong positive correlation between the VA values obtained from both eyes by pVEP (VA-pVEP) ($r=0.858$, $p<0.001$). There was a weak positive correlation ($r=0.267$, $p<0.001$) between the VA measured by the Snellen chart and the VA measured by the sVEP (VA-sVEP). A weak positive correlation was found for the VA-pVEP and VA-sVEP ($r=0.313$, $p<0.001$) (Table 1).

Discussion

The VEP is a sensitive test used to evaluate the optic nerve functions and is valuable in diagnosing optic nerve diseases such as demyelinating disease, optic neuritis, and optic neuropathy. In addition, it can be used to measure visual function by transmitting the ganglion cell response, which is formed by the flash or pattern stimulus, to the occipital cortex [1-6].

Two types of records can be done according to the type of stimulus, fVEP and pVEP, in the patients with low VA. The former is used to understand, if the visual cortex receives any messages from the retinal layer by the flash light stimuli. The latter is used to determine organic lesions in the upper visual pathways. The visual cortex neurons are more sensitive to the lines and corners than the flash. Therefore, checkerboard-pattern stimuli are used in the pVEP [6,7].

Two negative and two positive waves are obtained in the VEP. The most important wave is the p 1 (p100) wave. It typically occurs in the 100th milliseconds. The amplitude also plays a critical role in the VA evaluation, while latency gains importance for the evaluation of any type of lesions. In general, latency may vary 2 to 5%, amplitude may vary up to 25% [6,7]. Therefore, latency is a more reliable parameter for any occasion. Furthermore, pVEP are used to assess the function of the optic nerve in the unexplained vision loss, optic nerve disease, neurological diseases, simulation and hysteria, hemianopic field defects, vascular disease. It is the main tool for the clinician in cases of functional loss of vision which precludes VA examination and in non-cooperative cases [7,8].

The reliability of a test is established by repeating the test at two different points in a given subject. The reproducibility of the pVEP in a given same case is relatively high. In addition, the waveform, amplitude, and latency variations are low, when performed with standardized methods in normal individuals [1-7].

However, there are important considerations for the conduction of these tests. The waveforms are similar in VEP records which are obtained in accordance with the ISCEV standards; however, each electrophysiology laboratory should make its own normal data according to the age groups and should perform evaluations accordingly. In addition to the standard record environment, correcting the refractive error and providing fixation are necessary. During the VEP record, if the pattern stimuli are to be used, it is important that a patient is tested with the corrected refractive error. Refractive errors will affect the interpretation of the VEP results. Another important issue is that the follow-up of the patient during the record of electrodiagnostic tests. In the contrast stimulation, such as pVEP and pattern electroretinogram (pERG), it is critical for the patients to look at the fixation point in the middle of the monitor. Fixation may lead to shift tests to be completely abnormal. In addition, the patient should not look at the fixation point in a pensive manner, called de-accommodation. With de-accommodation, normal individuals can make pVEP responses completely abnormal [9].

The pVEP test substantially reflects the function of the macula in the presence of normal visual pathways. This is because, in the macula and fovea region, while each photoreceptor transmits a stimulus to one ganglion cell, towards the periphery, dozens and even hundreds of photoreceptors transmit to a single ganglion cell. In addition, although the fibers arising from the macula are represented in 50% of the occipital cortex, the entire peripheral retina is represented in a much smaller region. This is called the cortical magnification phenomena. Besides these, while the fibers arising from the macula are represented in the superficial part of the occipital cortex, the fibers from the peripheral retina are represented in the depths of the sulci [8].

The use of flash stimuli in patients with functional visual loss is more useful in patients with very low vision. Since the patient needs to look at the fixation point in the VEP test with pattern stimulus. In case of complete loss of vision, the patient is unable to fix. As a result of flash stimulus, the entire retina is stimulated and the response generated in the retina is transmitted to occipital cortex. Even any generated wave morphology will give information about the patient's vision. However, in clinical practice, patients with functional visual loss rarely present with complete loss of vision. As in case of complete loss of vision, the patients come to a position where they are unable to move and they put themselves into an unwarranted trouble. Therefore, in patients who present partial vision loss, with fVEP test, it gains importance that how much they can see, but not whether they can see. In this sense, the pVEP test gains value [9]. There are several studies in the literature about the use of the pVEP test in objective determination of VA. To the best of our knowledge, the first study was conducted by Halliday [11]. The author reported that he obtained symmetrical pVEP response in a patient with functional visual loss who was admitted with a complaint of asymmetric visual loss. In another study, Halliday and McDonald [11] reported that a pVEP with a good wave morphology is not absolutely consistent with a VA worse than 1/10 [11]. In a study conducted in the office setting, the authors concluded that the pVEP test recorded in different sizes could be used safely in cases of functional loss of vision. Jeon et al. (12) performed a pVEP test to identify the degree of visual disability and reported that the pVEP was useful for confirming VA [12].

The sVEP test, which can be only used in the laboratory setting in accordance with the ISCEV VEP 2009 standards, is a VEP type and is used for rapid evaluation of the visual function. The ISCEV also supports the implementation of sVEP and VEP tests performed by various techniques, and states that the tests can be standardized by the updates over the years. Firstly, Regan [13] described this new sVEP technique to objectively measure refractive errors. Subsequently, the test technique was improved to measure VA (14-15). Currently, it has been used in the evaluation of various ocular and systemic diseases in children [16-18]. As it is a rapid tool, it is also used in selected adults for the objective measurement of the VA [19-23].

Although there are standards for the sVEP records determined by the ISCEV, the placement of the electrodes in the majority of studies is as described for the VEP in ISCEV standards. In literature, many studies conducted in infants have tested that the changes in test distance, luminance and the placement of electrodes whether change the sVEP threshold; however, it has been shown that the standards specified for the VEP by the ISCEV can be used [13,24-29]. In their study, Arai et al. [24] found a correlation between the VA assessed by the Snellen chart and sVEP in various ocular diseases. In a recent retrospective study, Bradfield et al. [26] reported that the acuity of sVEP could be used to predict future VA in children with albinism [26]. Vedentham et al. [28] also reported that clinical use of the test in children might be beneficial, due to the ease of use and the short test duration.

In our laboratory, pVEP is used primarily to determine the degree of VA; however, sVEP is used in infants and in cases with short attention span and in non-cooperative cases. In this study, the pVEP was highly correlated with the Snellen chart (r=0.858) in the measurement of VA, and the reproducibility and reliability of the test was found to be high (Fig. 1). Furthermore, the sVEP can be used in infants and in non-cooperative cases due to the short test duration and the ease of use. When sVEP was compared with the Snellen chart, we found a weak positive correlation. When the VA by the pVEP and sVEP were compared, we found a positive, significant, but weak correlation. The advantage of quickly recording thresholds in this test is that it enables a new and reliable (reproducible) test to examine visual development. Although the VA measured by sVEP showed a weak correlation according to pVEP, it is valuable for the follow-up of brain development in infants. Thus, sVEP is a test which can be used for the diagnosis and follow-up of infants and for non-cooperative patients, rather than a test that can be used for screening.

The ISCEV also supports the implementation of sVEP and VEP tests performed by various techniques, and notes that the tests can be standardized by the updates over the years. The different outcomes from different studies may be prevented by standardization. In addition, we performed sVEP measurement using the same technique in our laboratory. Further studies using different techniques which are standardized by the ISCEV are needed to achieve more robust correlation with VA.

In conclusion, in the objective measurement of the VA, flash VEP (fVEP) can be used to evaluate the vision in patients with a VA of less than 1/10 with Snellen chart. Based on our study results, it seems reasonable to use pVEP initially to accurately assess the degree of the VA; however, sVEP should be used

in cases with short attention span and those who are non-cooperative and in infants. Nonetheless, further, large-scale studies are needed to confirm these findings.

Declarations

-The study belongs to one author

-Conflict of Interest: The author declare no conflict of interests.

-Ethical approval: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and national research committee (**SBU Ankara Numune Training and Research Ethical committee**) and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

-Informed consent: Informed consent was obtained from all individual participants included in the study.

- The author has not financial or proprietary interests in any material or methods mentioned.

-No funding was received for this research.

- The contents of this manuscript have not been copyrighted or published previously.

- The contents of this manuscript are not now under consideration for publication elsewhere.

References

1. Sokol S. Visually evoked potentials: theory, techniques and clinical applications. Surv Ophthalmol.1976;21(1):18–44. doi: 10.1016/0039-6257(76)90046-1. [PubMed] [Cross Ref]

2. Weinstein GW. Clinical aspects of the visually evoked potential. Ophthalmic Surg. 1978;9(1):56–65. [PubMed]

3. Arden GB, Lewis DR. The pattern visual evoked response in the assessment of visual acuity. Trans Ophthalmol Soc U K. 1973;93:39–48. [PubMed]

4. Seiyul Oh JJ, Kyung S. Assessment of visual disability using visual evoked potentials. Journal: BMC Ophthalmology, 2012, 12 (1), 36 DOI: 10.1186/1471-2415-12-36

5. Szabela DA, Pałenga-Pydyn D.Usefulness of visual evoked potentials in visual acuity examination]. Klin Oczna. 2001;103(2-3):141-5.

6. Odom JV, Bach M, Brigell M, Holder GE, McCulloch DL, Mizota A, Tormene AP. ISCEV standard for clinical visual evoked potentials. (2016 update). Doc Ophthalmol. 2016;133(1):1-9.

7. Harding GFA. Visual evoked cortical potentials.(1991) Basic recording. In: Heckenlively JR, Arden GB, eds. Principles and Practice of Clinical Electrophysiology and Vision. Mosby Year Book, St Louis, 398-407

8. Gündoğan FÇ, Sobacı G, Erdurman C, Hamurcu MŞ ark. The correlations between simultaneously recorded pattern visual evoked cortical potentials and pattern electroretinogram. Gulhane Med J. 2009; 51(1): 34-38.

9. Freitas Dotto P, Cavascan NN, Berezovsky A., et al. Neurol. 2014. 18 (2), 201–210

doi: http://dx.doi.org/10.1016/j.ejpn.2013.11.008 |

10. Gundogan FC, Sobaci G, Bayer A. Pattern visual evoked potentials in the assessment of visual acuity in malingering. Ophthalmology.2007;114(12):2332-7.

11. Halliday AM, McDonald WI: visual evoked potentials. In stalberg E,Young RR (eds): Neurology I: Clinical Neurophysiology. London, Butterworths, 1981,pp 228-258

12. Jeon J, Oh S, Kyung S. Assessment of visual disability using visual evoked potentials BMC Ophthalmol. 2012; 12: 36. doi: 10.1186/1471-2415-12-36

13. Regan, D. Rapid objective refraction using evoked brain potentials. Invest. Ophthalmol.1973;12,669–679.

14. Tyler, C. W., Apkarian, P., Levi, D. M. and Nakayama, K. Rapid assessment of visual function: an electronic sweep technique for the pattern visual evoked potential. Invest. Ophthalmol. Vis. Sci. 1979; 18,703–713.

15. Tyler, C. W., Nakayama, K., Apkarian, P. and Levi, D. M. VEP assessment of visual function. Vision Res.1981; 21, 607–609.

16. Norcia AM, Tyler CW, Piecuch R, Clyman R, Grobstein J. Visual acuity development in normal and abnormal preterm human infants. J Pediatr Ophthalmol Strabismus 1987; 24(2): 70-4. 6.

17. Hamer RD, Norcia AM, Tyler CW, Hsu-Winges C. The development of monocular and binocular VEP acuity. Vision Res 1989; 29(4): 397-408. 7.

18. Gottlob I, Fendick MG, Guo S, Zubcov AA, Odom JV, Reinecke RD. Visual acuity measurements by swept spatial frequency visual-evoked-cortical potentials (VECPs): clinical application in children with various visual disorders.J Pediatr Ophthalmol Strabismus 1990; 27(1): 40-7.

19. Thompson DA, Moller H, Russell-Eggitt I et al. Visual acuity in unilateral cataract. Br J Ophthalmol.1996;80:794-798 51.

20. Katsumi O, Arai M, Wajima R et al. Spatial frequency sweep pattern reversal VER acuity vs snellen visual acuity: effect of optical defocus. VisionRes 1996; 36:903- 90952.

21. Strasburger H, Remky A, Murray IJ et al. Objective measurement of contrast sensitivity and visual acuity with the steady-state visual evoked potential. Ger J Ophthalmol . 1996; 5:42-52.

22. Ridder WH 3rd, McCulloch D, Herbert AM . Stimulus duration, neural adaptation, and sweep visual evoked potential acuity estimates. Invest Ophthalmol Vis Sci 1998;39(13):2759-2768.

23. Ridder WH 3rd (2004) Methods of visual acuity determination with the spatial frequency sweep visual evoked potential. Doc Ophthalmol, 2004; 109(3):239-247

24. Arai, M., Katsumi, O., Paranhos, F. R. L., De Faria, J. M. L. and Hirose, T. Comparison of Snellen acuity and objective assessment using the spatial frequency sweep PVER. Graefes Arch. Clin. Exp. Ophthalmol.1997;235, 442–447.

25. Allen, D., Bennett, P. J. and Banks, M. S. The effects of luminance on FPL and VEP acuity in human infants. Vision Res. 1992;32, 2005–2012.

26. Bradfield, Y. S., France, T. D., Verhoeve, J. and Gangnon, R. E. Sweep visual evoked potential testing as a predictor of recognition acuity in albinism. Arch. Ophthalmol. 2007; 125, 628–633.

27. Ridder WH, Rouse MW. Predicting potential acuities in amblyopes: Predicting post-therapy acuity in amblyopes. Doc Ophthalmol. 2007;114(3):135-45.

28. Vedentham V, Ratnagiri PK. The Sweep-VEP: A faster estimation of visual acuity in preverbal children. Indian J Ophthalmol 2004; 52:175-17

29. Prager, T. C., Zou, Y. L., Jensen, C. L., Fraley, J. K., Anderson, R. E. and Heird, W. C. Evaluation of methods for assessing visual function of infants. J. AAPOS 1999; 3, 275–282.

Table

Table 1 not found