ARTICLE TYPE

Full- Field Electroretinogram (ffERG) on Color Vision Deficiency

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Abstract:

This study aimed to describe the electrophysiological respond of amplitude and latency time using full-field ERG (FfERG) among colour vision deficiency. Twelve eyes of colour vision deficiency subject were recruited in this study which the mean age of the subjects was 22.0 ± 1.41 years. Psychophysics colour vision test was done by using Nagel Anomaloscope. Room illumination was photopic adapted for 10 minutes, then single flashes of 3 cd.s.m^{-2} presented until four similar artefacts-free ERG waveforms, which based on ISCEV 2015 protocol. All the data were analysed using a one-sample t-test, which was compared to the normative test value. Cone a-wave amplitude (μV) was statistically significant higher by 31.65, 95% CI [21.74, 41.55], p=0.00 than a normal cone a-wave amplitude of -30.73 μV. Meanwhile, cone a-wave latency time (ms) shows statistically significant higher by 0.92, 95% CI [0.05, 1.79], p=0.04 than a normal cone a wave latency time of 14.30 ms. Also, cone b-wave amplitude (μV) shows a significant lower by -107. 95% CI [-136.94, -77.63], p=0.00 than a normal cone b-wave amplitude of 119.26 μV. FfERG techniques ability to detect any abnormality that occurred in the retina and visual pathway related to vision.

Keywords: amplitude and latency time, colour vision deficiency, electrophysiology, ffERG, ISCEV.

1. INTRODUCTION

Normal colour vision used all three types of light cones accurately known as trichromacy. Human retina consisted of two types of photoreceptor, which were rod and cone. Rod photoreceptors were playing a role in the vision for dim light whereas cone photoreceptor responsible in bright light. People with normal colour vision have three types of cone photoreceptors, which consisted of short sensitivity or blue, middle sensitivity or green and long sensitivity or red cones[1]. Each of cones has different spectral sensitivity, which was the foundations of normal trichromatic colour vision [2]. Pigments inside the cone can differ colours and send output through the optic nerve to the brain based on light wavelength [3]. However, if cones lack one or more light-sensitive pigments, disturbance of three primary colours occurred, knowns as colour vision deficiency[4].

Visual electrophysiological testing could provide information in a variety of cases and used in the acceptance of diagnosis for patient's symptom. It also aids in pediatric clinician assessment for a young child with apparent poor vision and the ophthalmologist dealing with unexplained visual loss in children and adults [5]. In addition, it possible to identify the lesion occurs in the globe, optic chiasm, and optic nerve, that identified rod and cone involvement [6]. For example in retinitis pigmentosa, which was heterogeneous disease that has been associated with a mutation in different genes and related with progressive retinal degeneration [7].

Using the full-field Electroretinogram (ffERG), it is an important clinical tool for diagnosing and observing retinal disease likes retinitis pigmentosa (RP) which was related with photoreceptor dysfunction and retinal pigment epithelium that causes inherited progressive retinal conditions [6]. So, ffERG would be suitable to aid in differentiating between rod-cone and cone-rod degenerations.

Most of the colour vision test battery use photopic conditions as the test lighting environment. Using the ffERG, the electrophysiology responds of a respective cone in amplitude and implicit time could be described and compared to normal colour vision.

2. METHODOLOGY

This study was conducted at the Advanced Electrophysiology Eye Center (AEeC), Center of Excellence for Research in Optometry & Vision Science (iROViS), Universiti Teknologi MARA (UiTM), Malaysia. Six of Malay colour vision deficiency subjects from aged 21 to 23 years old, who were 4 males and 2 females. All the subjects selected via simple convenience sampling, which was through the

previous colour vision clinic record from the UiTM Optometry Clinic. All the subjects had diagnosed as colour vision deficiency and confirmed again by colour matching test Nagel Anomaloscope. The ethical consideration had been approved by the Universiti Teknologi MARA (UiTM) and followed the tenet of the Helsinki Declaration.

All the subjects have a minimum visual acuity of 6/6 for distance and N6 for near with habitual vision. Besides that, subjects were free from eye-related disease likes diabetes, macular degeneration, Glaucoma, Retinitis Pigmentosa, and systemic diseases that might jeopardise the retinal integrity and photoreceptor response.

The ffERG investigation started with the dilation of both pupils of the subjects using 2 drops of 1.0% Tropicamide (Mydriacyl; Alcon Laboratories, USA) instilled in 5 minutes gap between each drop. Before each of the ffERG examinations took place, the machine had been set to calibrate automatically. Full-field ERG was analysed on the computerised Opto-electronic Stimulator Vision Monitor Mon-Pack One Metrovision (Pérenchies, France) and the ffERG subject preparation and protocols for photopic stimulation followed the ISCEV Standard 2015 set by the International Society for Clinical Electrophysiology of Vision (ISCEV) [8]. After full dilation, the subject was on light adaptation in room illumination for 10 minutes. After light adaptation, the pupil size of the subjects was measured with conventional pupillary size ruler, before performing photopic ffERG. Photopic ffERG protocols included single flashes of 3 cd.s.m^{-2} that were presented until 4 similar artefact-free ERG waveforms were obtained and averaged (the Cone ERG). Also, later on, 30 Hz flickers ERG was averaged based on 15 sweeps of 250 milliseconds duration (the 30 Hz Flicker ERG).

The outcome of ffERG on cone a-wave amplitude, latency time, cone b-wave amplitude and latency time of colour vision deficiency was compared using a one-sample t-test, by the normal colour vision from previous study [9].

3. RESULT AND DISCUSSION

The mean age of the subjects was 22.0 ± 1.414 years. From the colour-matching test by the Nagel Anomaloscope, found that the majority of the subject's colour vision deficiency was anomalous trichromacy, which was protanomaly and deuteranomaly. The others were classified as deuteranope. Table 1 showed the classification of colour vision deficiency using the Nagel Anomaloscope.

The summary of the mean, standard deviation and median for cone a-wave amplitude, cone a-wave latency time, cone b-wave amplitude and cone b-wave latency time for photopic of the 12 eyes ffERG were presented in Figure 1. Table 2 showed the significant difference between the ffERG on colour vision deficiency towards the normative test value done by a previous study [9]. No significant difference was reported for cone b-wave latency time.

Table 1: Classification of the types of colour vision deficiency and severity among the subject from the Nagel Anomaloscope grouping.

Types of colour vision deficiency	Severity	Subjects
Deuteranope	Severe	1
Protanomaly	Mild	2
	Severe	1
Deuteranomaly	Mild	1
	Severe	1

Table 2: Summary of the significant value of colour vision defect photopic adapted ffERG

	Cone a-wave amplitude (μV)	Cone a-wave latency time (ms)	Cone b-wave amplitude (μV)	Cone b-wave latency time (ms)
Mean	0.92	15.22	11.98	28.54
SD	15.59	1.37	46.67	5.01
Normative Test value [9]	-30.73	14.30	119.26	30.02
Mean diff.	31.65	0.92	-107.29	-1.48
tc	7.03	2.32	-7.96	-1.02
sig. (2-tailed)	*0.00	*0.04	*0.000	0.33
Lower 95% CI	21.74	0.05	-136.94	-4.66
Upper	41.55	1.79	-77.63	1.71

Std. Error: standard error, tc: standardised difference, sig. (2-tailed): two-tailed p-value of the test, CI: confidence interval of difference. *Show significance difference.

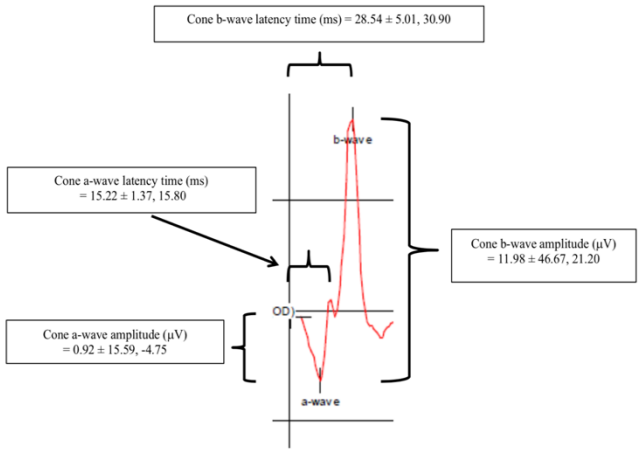

Figure 1: The mean, standard deviation (SD) and median for photopic adapted cone responses (indication: mean ± SD, median) of the cone a-wave amplitude (μV), cone a-latency time (ms), cone b-amplitude (μV) and cone b-latency time (ms) for color vision deficiency. The illustration in figure did not represent the real qualification of ffERG reading

This study found the mean value of colour vision deficiency was lower than normal value in cone a-wave amplitude, cone a-wave latency time, and cone b-wave amplitude. The same condition resulted for those people who had retinitis pigmentosa, which was the amplitude presumably was reflected mainly the total number of functional photoreceptors and the amplitude of the ERG

decreases as the number of photoreceptors in the retina decrease in retinitis pigmentosa progresses, that related with retina disease [10].

Currently, the diagnosis in patients for colour vision deficiency was subjectively measured based on psychophysics method from the patient. Studies had shown that there was a lot of colour vision test in specific illumination. However, the electrophysiology respond of specific cone function functions was relatively unknown. In recent years, non-invasive objective diagnostic tools for the quantitative assessment of the macula have been developed and introduced into clinical ophthalmology. Full-field Electroretinogram (ffERG) could provide objective quantification of electro retinal function from within the macular region. FfERG was an objective, non-invasive technique that has proven utility in assessing macular function in age-related macular degeneration, in patients with vitreomacular traction, macular holes, epiretinal membranes, and in patients with diabetic macular oedema.

4. CONCLUSIONS

Colour perception perceive from the central vision, which stimulated by the three types of cone. The anatomical and physiological process on how each cone stimulates the signal could be gathered from the ffERG technique. The future study can be done on how to standardise objectively and subjectively especially in the critical colour vision needs, such as in transportation, signal light perception, engineering and hence find the solution on how to enhance colour vision performance.

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