Electroretinography with the RM Electrode: Normal Values, Variation with Age and Comparison with the Burian-Allen Electrode

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Purpose

The RM Electrode (RETMAP INC) is a new, soft-contact lens based single-use electrode for recording the full-field electroretinogram (ffERG). Aim 1 was to define the normal range with the RM Electrode for ERGs recorded to the International Standard of Clinical Electrophysiology of Vision (ISCEV) protocols. Aim 2 was to compare ERG parameter values from the RM Electrode with the Burian Allen (BA) contact lens electrode.

Methods

ffERGs were recorded from 40 healthy volunteers aged between 21 to 74y (mean ± SD = 39.4 ± 15.7y). Following pupil dilation and 30 min of dark adaptation, ISCEV standard ffERGs were recorded from an RM Electrode placed on the cornea; skin electrodes placed on the outer canthus and forehead served as reference and ground respectively. ffERGs were also recorded for 4 ISCEV extended protocols: DA red flash, photopic negative response to red on blue ($PhNR_{RB}$) and blue on yellow ($PhNR_{BY}$), photopic On-Off and S-cones. ISCEV ffERGS were simultaneously recorded from a BA electrode in the contralateral eye in a subset of HVs (N=22)

Results

Scotopic ERG amplitudes as well as PhNR and S-cone ERG amplitudes followed a log-normal

distribution. Photopic amplitudes recorded to achromatic light and all implicit times were normally distributed. Tables 1 and 2 summarize the normal ranges for amplitudes and implicit times respectively. Log values are converted to linear equivalents. Some scotopic amplitudes (Table 1: DA01, DA3/10 a-wave, OPs & On-Off d-wave) and most implicit times (Table 2) varied with age. Therefore, the mean ± SD, and the lower limit of normal, are shown for a nominal age of 20y. The last columns in Tables 1 and 2 show the decrease in amplitude and increase in implicit time per decade respectively, for those parameters that varied with age. DA3 and LA3 amplitudes were 18% and 20% larger from the RM Electrode compared with the BA electrode; there were no differences in implicit times. However, when the BA electrode was used in a monopolar configuration (i.e. equivalent to the RM Electrode) there were no differences in amplitudes between the two electrodes.

Conclusions

We defined the normal range from the RM Electrode for the standard ISCEV ERG protocol and four extended ISCEV protocols. ERG amplitudes and implicit times were equivalent from RM and BA electrodes when used in a monopolar configuration.

Table 1 - Normal ranges of amplitudes (MonCvONE-CR and RETMAP electrode)

Parameter	Correlation with age	Mean ± SD at 20y (µV)	Lower limit 20y (µV)	reduction per decade (%)
DA red	NS	129 ± 34	72	--
DA01	P<0.0001; R^2 = 0.36	372 ± 99	209	12
DA3 a-wave	P=0.006; R^2 = 0.19	321 ± 73	201	7
DA3 b-wave	NS	490 ± 98	329	--
DA10 a-wave	P=0.029; R^2 = 0.13	389 ± 83	252	6
DA10 b-wave	NS	500 ± 104	329	--
OPs	P<0.0001; R^2 = 0.44	241 ± 86	99	21
LA3	NS	182 ± 55	91	--
30 Hz	NS	143 ± 51	58	--
On_OFF b-wave	NS	75 ± 27	30	--
On_OFF d-wave	P=0.04 R^2 = 0.13	65 ± 25	24	11
PhNR$_{R/B}$	NS	33 ± 9	17	--
PhNR$_{B/Y}$	NS	64 ± 22	27	--
S-Cone	NS	5.7 ± 1.9	2.5	--

Table 2 - Normal ranges of implicit times (MonCvONE-CR and RETMAP electrode)

Parameter	Correlation with age	Mean ± SD at 20y (ms)	Lower limit 20y (ms)	increase per decade (ms)
DA red	P=0.039: R^2 = 0.14	46.2 ± 3.7	52.3	0.9
DA01	NS	94.0 ± 8.7	108.3	--
DA3 a-wave	P<0.005; R^2 = 0.20	19.2 ± 1.5	21.7	0.4
DA3 b-wave	NS	49.6 ± 3.8	55.9	--
DA10 a-wave	P<0.0001; R^2 = 0.50	11.3 ± 1.2	13.3	0.5
DA10 b-wave	NS	51.9 ± 6.0	61.8	--
LA3	NS	28.5 ± 1.5	31.0	--
30 Hz	P=0.001; R^2 = 0.25	24.0 ± 2.2	27.6	0.7
On_OFF b-wave	P=0.006; R^2 = 0.20	31.0 ± 4.0	37.6	1.2
On_OFF d-wave	p=0.018; R^2 = 0.17	19.9 ± 1.4	22.2	0.4
PhNR$_{R/B}$	p=0.01; R^2 = 0.20	61.6 ± 5.7	70.9	1.7
PhNR$_{B/Y}$	NS	108 ± 18	137.7	--
S-Cone	NS	38.2 ± 2.7	42.6	--