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Preoperative Electroretinogram and Postoperative Visual Outcome in Patients with Diabetic Vitreous Hemorrhage

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Purpose: To determine whether the single-flash electroretinogram (ERG) can predict the postoperative outcome in diabetic cases where massive vitreous hemorrhage precludes fundus observation.

Methods: Eighty-five diabetic patients (105 eyes) who underwent vitrectomy due to dense vitreous hemorrhage were studied retrospectively. Eyes with postoperative complications were excluded. Preoperative ERGs (mixed cone-rod ERG with maximum flash intensity) were classified as: Group A, the b-wave/a-wave ratio (b/a ratio) was $\geq$1.0 and the oscillatory potentials (OPs) were clearly recordable (22 eyes); Group B, the b/a ratio was $\geq$1.0 and the OPs were markedly reduced (33 eyes); and Group C, the b/a ratio was $<$1.0 (50 eyes).

Results: The postoperative visual acuity in Group C (hand motion to 1.5) was significantly worse than in Group A (0.4–.2) ($P < .01$) or Group B (0.08–1.0) ($P < .01$). Thick preretinal membrane causing retinal traction around the optic disc was found intraoperatively in 1 eye (4.5%) in Group A, 9 eyes (27.3%) in Group B, and 28 eyes (56.0%) in Group C ($P = .0132$).

Conclusion: Our findings suggested that the configuration of the single-flash ERG can provide important preoperative information for a functional prognosis following vitrectomy in diabetic patients with vitreous hemorrhage. **Jpn J Ophthalmol 2003;47:307–311**

Key Words: Diabetic retinopathy, electroretinogram, vitrectomy, vitreous hemorrhage.

Introduction

When massive vitreous hemorrhage prevents inspection of the ocular fundus in patients with proliferative diabetic retinopathy, it is difficult to predict visual outcome after vitrectomy. Although ultrasonography can be used to demonstrate retinal detachment,[1] it provides no indication of the functional status of the attached retina. Standard clinical tests including color perception, two-point discrimination, and Maddox rod orientation have limited value in evaluating such patients.[2] It has been reported that the electroretinogram (ERG)[1,3,4] and visual evoked potentials (VEP)[1,5] are useful in predicting visual outcome following vitrectomy, however, these results are of limited value because vitreous hemorrhage or photocoagulation could influence the amplitudes of the ERG or the stimulus intensity in proliferative diabetic retinopathy.[6]

The amplitudes of a- and b-waves in a single flash ERG have been markedly reduced after panretinal photocoagulation (PRP).[7,8] Because most patients with vitreous hemorrhage have undergone PRP, it is difficult to evaluate the prognosis of vitrectomy by using only the a- or b-wave amplitude. Hirose[3] has recommended using the ratio of b- to a-wave amplitudes (b/a ratio) and has reported that eyes showing a ratio $>$1.0 had a better chance of improved vision after surgery. Summanen[4] also has reported that a nonrecordable b-wave in the flash ERG was associated with a poor visual outcome. The b/a ratio of the preoperative ERG appears to be important in predicting

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the visual outcome in patients with diabetic vitreous hemorrhage. It has also been known that the peak time of the first wavelet of the oscillatory potentials (OPs) in the ERG is delayed and that the sum of the OP amplitudes decreases progressively with the advancement of the retinopathy.[6,9–12] Thus, the preoperative OPs are an additional consideration in visual prognosis following vitrectomy.

In this study, we used single-flash ERG preoperatively and classified patients based on the b/a ratio and the OP amplitudes. Thereafter, we evaluated the relationship between the preoperative ERG and the postoperative visual acuity to study the predictability of single-flash ERGs for postoperative visual outcome in diabetic patients in whom massive vitreous hemorrhage obstructs fundus observation.

Materials and Methods

One hundred and two consecutive patients (129 eyes) who underwent vitrectomy for vitreous hemorrhage due to proliferative diabetic retinopathy and were followed-up for at least 3 months were studied retrospectively. Eyes with preoperative neovascularization of the iris (n = 7), and eyes with postoperative complications that could independently reduce the postoperative visual acuity (n = 17), such as corneal opacity and rubeotic glaucoma, were excluded from this study. Therefore, 85 patients (105 eyes), 48 men and 37 women, with dense vitreous hemorrhage that prevented inspection of the fundus were included. The preoperative visual acuity ranged from light perception to 0.6. The age of the patients ranged from 30 to 80 years (mean ± SD = 55.1 ± 10.3 years).

To conduct the ERGs, the patient's pupil was dilated with 0.5% tropicamide and 0.5% phenylephrine. The preoperative ERGs were recorded by using a 20-J single-flash light (PE-3000; Tomey, Nagoya) after 30 minutes of dark adaptation. Responses were bandpass-filtered between 0.7 Hz and 1000 Hz. Preoperative ERGs (mixed cone-rod ERG with maximum flash) were classified (Figure 1) as: Group A, the b-wave/a-wave ratio (b/a ratio) was ≥1.0 and the OPs were clearly recordable; Group B, the b/a ratio was ≥1.0 and the OPs were markedly reduced; and Group C, the b/a ratio was <1.0. The ERGs with reduced amplitudes of OP1 and OP2, and nonrecordable OP3 were assumed to have markedly reduced OPs. Interestingly, all eyes classified into Group C had nonrecordable OPs. The ERGs were classified manually by a masked observer (one of the authors, TS).

All patients had undergone ophthalmic evaluation in our department, including the measurement of best-corrected visual acuity by decimal chart, slit-lamp biomicroscopy, and ophthalmoscopy. Pars plana vitrectomy was performed with endophotocoagulation. Phacoemulsification (sclerocorneal incision or pars plana phacoemulsification leaving the anterior capsule), membrane peeling, fluid–gas exchange, and temporal gas or silicone oil tamponade had been performed, when necessary (Table 1). The retinal pathologic changes were evaluated during the surgery by examining for proliferative membranes at the disc, retinal folds on the macula, and tractional retinal detachment (TRD). The best postoperative visual acuity had been obtained during the follow-up period from 3 to 44 months (15.3 ± 10.7 months) after surgery.

The visual acuity in each group was compared using the Kruskal–Wallis one-way factorial analysis of variance on ranks and the Dunn test for multiple comparison. To analyze the existence of proliferative membrane at the disc, the Fisher exact probability test was used to determine the significance between Groups B and C. Values of $P < .05$ were considered statistically significant.

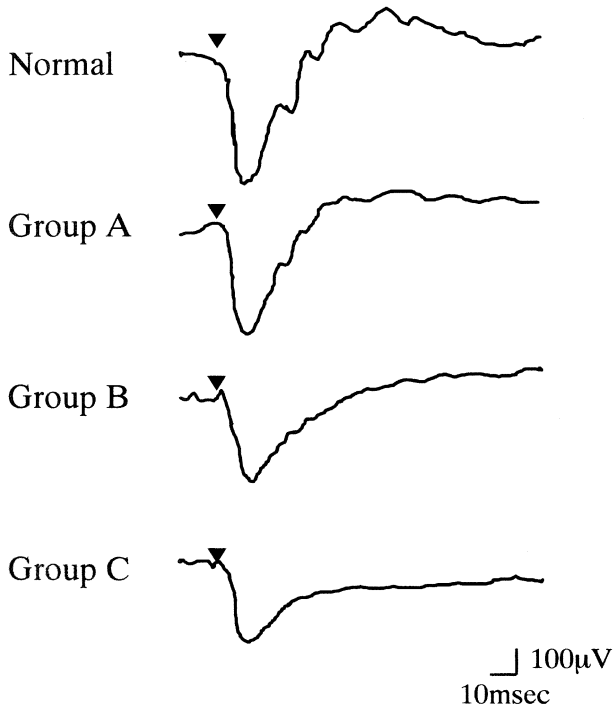

Figure 1. Classification of preoperative electroretinograms (ERGs) in three groups of diabetic patients with vitreous hemorrhage, and comparison with normal values. Group A: the b-wave to a-wave peak (b/a) ratio was ≥1.0 and the oscillatory potentials (OPs) were clearly recordable. Group B: the b/a ratio was ≥1.0 with markedly reduced OPs. Group C: the b/a ratio was <1.0 and the OPs were nonrecordable. Arrowhead indicates stimulus onset.

Table 1. Data on Patients and Results

		Number of Eyes by Group		
		A	B	C
Surgical procedure				
PPV, lens surgery				
No tamponade		13	15	12
Tamponade		2	9	22
PPV				
No tamponade		6	7	9
Tamponade		1	2	7
Age (mean, years)		31–69 (58.8)	30–80 (56.4)	36–80 (53.9)
Preoperative visual acuity (median)		HM–0.6 (0.055)	HM–0.4 (0.01)	LP–0.4 (CF)
Postoperative visual acuity (median)		0.4–1.2 (0.75)	0.08–1.0 (0.5)	HM–1.5 (0.2)
Proliferative membrane	–	14	11	5
	+	7	13	17
	++	1	9*	28*
Total (no of eyes)		22	33	50

PPV: pars plana vitrectomy, LP: light perception, HM: hand motion, CF: counting fingers, +: proliferative membrane at the optic disc without traction, ++: retinal folds on the macula or tractional retinal detachment around the optic disc. The ratio of tractional membrane (++ to − and +) in Group C is higher than that in Group B using the Fisher exact probability test (*P = .0132).

Results

The postoperative visual acuity in Group C (hand motion to 1.5, median = 0.2) was significantly worse than in Group A (0.4–1.2, median = 0.75) ($P < .01$) or Group B (0.08–1.0, median = 0.5) ($P < .01$) (Figure 2). There was no difference in postoperative visual acuity between Group A and Group B. On the other hand, the preoperative visual acuity in Group A (hand motion to 0.6, median = 0.055) was better than that in Group C (light perception to 0.4, median = counting fingers) ($P < .01$), although there was no difference between Groups A and B (hand motion to 0.4, median = 0.01) or between Groups B and C (Table 1). In 8 of the 22 eyes (36.4%) in Group A, in 19 of the 33 eyes (57.6%) in Group B, and in 33 of the 50 eyes (66.0%) in Group C, the fundus was not visible preoperatively. The other eyes in these three groups had a partially visible fundus or a visible disc with diffuse vitreous hemorrhage. There was no difference in the view of the preoperative fundus in the three groups using the chi-square test for independence.

A thick preretinal membrane at the disc was found intraoperatively in 8 of the 22 eyes (36.4%) in Group A, in 22 of the 33 eyes (66.7%) in Group B, and in 45 of the 50 eyes (90.0%) in Group C. TRD or retinal folds on the macula were found in 1 eye (4.5%) in Group A, 9 eyes (27.3%) in Group B, and 28 eyes (56.0%) in Group C. The ratio of tractional membrane with TRD or retinal folds on the macula was significantly higher in Group C than in Group B (P = .0132) (Table 1).

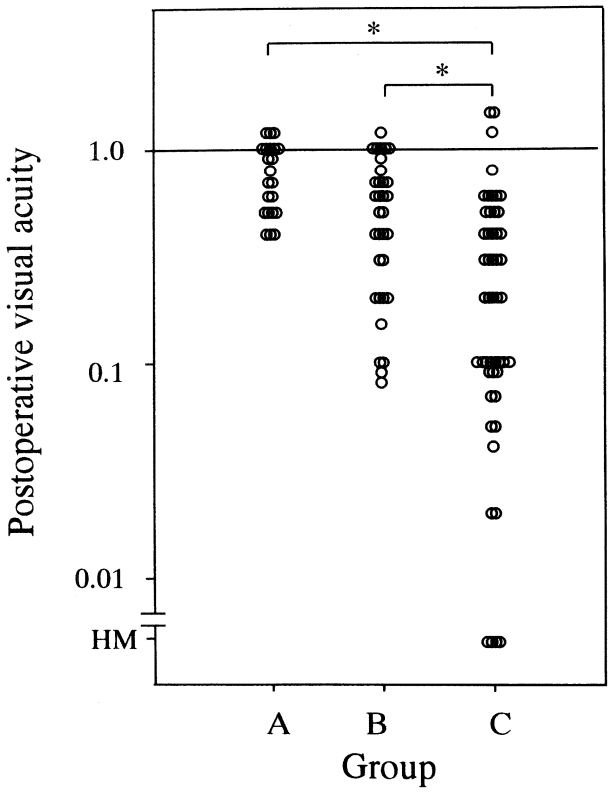

Figure 2. Postoperative visual acuity in each group. *$P < .01$. HM: hand motion.

Discussion

Previous reports[1,4] have indicated that a decreased b-wave amplitude correlated with poor outcome after vitrectomy, although they could not safely predict visual outcome. In the present study, we classified the eyes based on the b/a ratio and the OPs of the preoperative ERGs. Our data showed that eyes with a b/a ratio <1.0 (Group C) had worse postoperative visual acuity than eyes with a b/a ratio ≥1.0 (Group A and Group B). In evaluating preoperative ERGs, the influence of PRP on the ERG has been important because the amplitudes of a- and b-waves are markedly reduced after PRP. Previous reports[7,8] have demonstrated that both a- and b-wave amplitudes were significantly reduced following PRP, and that both the a-wave and the b-wave were reduced proportionally. These findings suggest that the outcome of vitrectomy could not be predicted accurately based only on the ERG amplitude,[1] and that the b/a ratio is probably a better prognostic index.

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Proliferative diabetic retinopathy has been associated with decreased amplitudes of both a- and b-waves. From a previous study,[3] a disproportionate decrease in the b-wave amplitude with little change in the a-wave, leading to a b/a ratio <1.0 would suggest fibrous proliferation at the disc, which may restrict circulation by compressing the central retinal artery. In this study, we did find thick tractional membranes at the disc in more eyes in Group C than in Group B. When the thick membranes caused retinal folds or TRD at the macula, the visual outcome was even worse. This preoperative retinal finding may explain the poor visual outcome in Group C. In addition, it has also been shown that the b/a ratio becomes <1.0 in central artery occlusion[13] and severe central vein occlusion.[14,15] A b/a ratio of <1.0 indicated the presence of severe ischemic changes in the retina. Therefore, the eyes in Group C probably had ischemic changes due to diabetic retinopathy, which also may have caused reduced retinal function and poor visual outcome following vitrectomy. Moreover, a recent study[16] has described the mechanisms of visual loss due to vitreopapillary traction on the nasal optic disc, suggesting damage to the anterior optic nerve via decreased axoplasmatic flow in the optic nerve fibers or mechanical reduction of perfusion in the posterior ciliary arteries. This study indicated that poor visual outcome with tractional membrane on the disc suggests ischemic damage to the optic disc as well as the retina.

The light-filtering effect of dense vitreous hemorrhage also should be considered in evaluating preoperative ERG in diabetic patients. Severe vitreous hemorrhage reduces the intensity of the stimulus light. As the stimulus intensity increases in a normal subject, both a- and b-waves become larger, but the b/a ratio becomes smaller, although it never was <1.0 even at the maximum intensity (Figure 3). Because the opaque media had the effect of reducing the stimulus intensity, the b/a ratio should increase in eyes with opaque vitreous. Therefore, a decreased b/a ratio in patients with opaque vitreous indicated extremely abnormal retinal function.[17] In addition, Group B may include eyes with recordable OPs which could be detected if there were no vitreous hemorrhage; the light-filtering effect of dense vitreous hemorrhage can reduce the OPs. In contrast, the eyes in Group A definitely had OPs in spite of dense hemorrhage.

The summed amplitude of the OPs was reported to be a predictor of progression to severe proliferative retinopathy.[11,18] We found that the postoperative visual acuity of eyes in Group A tended to be better than that of eyes in Group B, and the existence of proliferative membrane at the optic disc was greater in Group B than in Group A. These data suggested that patients in Group A have the possibility of a good visual outcome, which is very important information for patients with recordable OPs before vitrectomy.

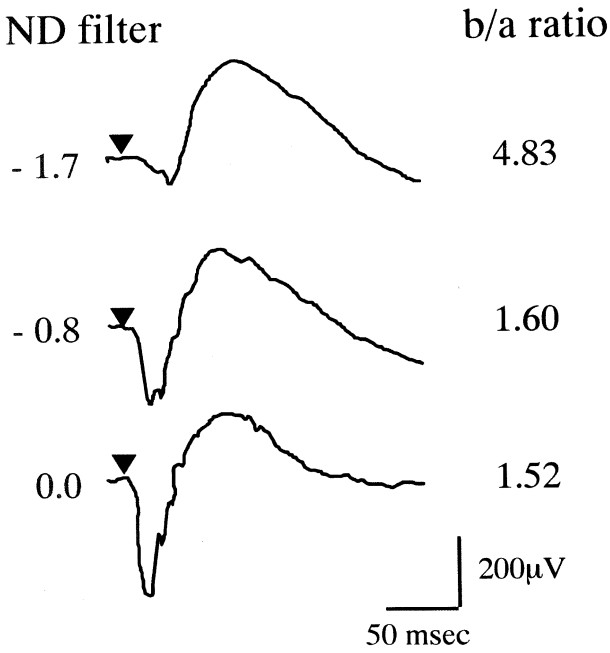

Figure 3. The influence of stimulus intensity on the electroretinogram (ERG). Single flash ERG was elicited from a normal subject by different stimulus intensities of the 20-J stimulus. Numbers at left indicate the density of neutral density filter in log units. Lowest tracing (0.0) is ERG recorded with maximum stimulus intensity. Because the opaque media has the effect of reducing the stimulus intensity, the b/a ratio should increase; a decreased b/a ratio in patients with opaque vitreous indicates extremely abnormal retinal function.

As single-flash ERG reflects the function from the entire retina, the configuration of the ERG does not always correlate to postoperative visual acuity. However, diffuse ischemic change, including thick proliferative membrane on the disc in diabetic retina indicated by ERG, may affect the visual acuity as is shown in this study.

In conclusion, our data showed that the single-flash ERG can provide a noninvasive assessment of retinal function before vitrectomy. Although it does not provide the indication for vitrectomy, single-flash ERG also helps to anticipate findings that will be encountered during surgery. The configuration of the ERG may be a useful index to predict visual outcome following vitrectomy for patients with diabetic vitreous hemorrhage.

References

1. Algvere P, Persson HE, Wanger P. Preoperative electroretinograms and visual evoked cortical potentials for predicting outcome of vitrectomy in diabetics. Retina 1985;5:179–183.

2. Mandelcorn MS, Blankenship G, Machemar R. Pars plana vitrectomy in severe diabetic retinopathy. Am J Ophthalmol 1976;81: 561–570.
3. Hirose T. Evaluation of retinal function in the presence of vitreous opacities. In: Vitreous surgery and advances in fundus diagnosis and treatment. New York: Appleton-Century-Crofts, 1977:79–97.
4. Summanen P. Vitrectomy for diabetic eye disease: the prognostic value of pre-operative electroretinography and visual evoked cortical potentials. Ophthalmologica 1989;199:60–71.
5. Schonfeld CL, Schneider T, Korner U, Heidenkummer HP, Kampik A. Prognostic factors in vitreous surgery for proliferative diabetic retinopathy. Ger J Ophthalmol 1994;3:137–143.
6. Tzekov R, Arden GB. The electroretinogram in diabetic retinopathy. Surv Ophthalmol 1999;44:53–60.
7. Liang JC, Fishman GA, Huamote FU, Anderson RJ. Comparative electroretinograms in argon laser and xenon arc panretinal photocoagulation. Br J Ophthalmol 1983;67:520–525.
8. Perlman I, Gdal-On M, Miller B, Zonis S. Retinal function of the diabetic retina after argon laser photocoagulation assessed electroretinographically. Br J Ophthalmol 1985;69:240–246.
9. Yonemura D, Aoki T, Tsuzuki K. Electroretinogram in diabetic retinopathy. Arch Ophthalmol 1962;68:19–24.
10. Shirao Y, Okumura T, Ohta T, Kawasaki K. Clinical importance of electroretinographic oscillatory potentials in early detection and objective evaluation for diabetic retinopathy. Clin Vis Sci 1991; 6:445–450.
11. Bresnick GH, Palta M. Predicting progression to severe proliferative diabetic retinopathy. Arch Ophthalmol 1987;105:810–814.
12. Bresnick GH. Diabetic retinopathy. In: Principles and practice of clinical electrophysiology of vision. St. Louis: Mosby Year Book, 1991:619–635.
13. Karpe G. The basis of clinical electroretinography. Acta Ophthalmol 1945;24(Suppl):1–118.
14. Sabates R, Hirose T, McMeel JW. Electroretinography in the prognosis and classification of central retinal vein occlusion. Arch Ophthalmol 1983;101:232–235.
15. Breton ME, Quinn GE, Keene SS, Dahmen JC, Brucker AJ. Electroretinogram parameters at presentation as predictor of rubeosis in central retinal vein occlusion patients. Ophthalmology 1989; 96:1343–1352.
16. Kroll P, Wiegand W, Schmidt J. Vitreopapillary traction in proliferative diabetic vitreoretinopathy. Br J Ophthalmol 1999;83:261–264.
17. Miyake Y, Hirose T, Hara A. Electrophysiologic testing of visual functions for vitrectomy candidates: results in eyes with unknown fundus diseases. Retina 1983;3:86–94.
18. Simonsen SE. Prognostic value of ERG (oscillatory potential) in juvenile diabetics. Acta Ophthalmol 1974;123(Suppl):223–224.