PREOPERATIVE ELECTROPHYSIOLOGICAL EXAMINATION AN INDICATOR OF VISUAL OUTCOME FOLLOWING PARS PLANA VITRECTOMY?

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Introduction

Progress of microsurgical techniques in vitreoretinal surgery recently led to an increased number of successful operations even in very difficult cases of proliferative vitreoretinopathy, perforating injuries and diabetic tractional detachments. These sophisticated techniques are time consuming and in most cases more than one operation in needed for the final functional success. The anatomical success however is not always paralleled by the functional recovery. Especially diabetic patients with long standing disease and e. g. renal dysfunction or other generalized diseases have an increased risk for complications after surgery. Confronted with the necessity of several operations, the patient and the surgeon are interested to know, to which extent functional recovery may be expected after successful surgery.

Subjective methods like visual acuity, light projection and entoptic phenomena are not contributing[13]. There are several papers concerning the usefulness of electrophysiological examinations[1)3)~6)8)~10)16)~21)], but the predictive value of these examinations in a given patient are discussed controversially. We therefore evaluated the functional outcome of a large number of consecutive vitrectomy patients compared with either electroretinogram (ERG) or visual evoked cortical potentials (VECP) or both.

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Electrophysiological Methods

Our electrophysiological methods have been described elsewhere[11)12)]. They were carried out according to the international standards[15)]. In short they are as follows: After 40 minutes of dark adaptation and with maximal possible dilation of the pupil (phenylephrine 2.5% and tropicamide 0.5%), the ERGs were recorded in the dark. Stimulus duration was 10 ms. Six different light intensities[1)~6)] increasing by one logarithmic unit from the b-wave threshold of the normal eye were used for the dark-adapted recordings. The maximum light intensity was 780 cd/m^2. The light-adapted recordings were performed under white light adaptation with 4.5 cd/m^2 and with the light stimuli 4–6. The 30 Hz flicker stimulus had the light intensity 5. White light from a filtered xenon light source served as stimulus in all examinations. The potentials were displayed on an oscilloscope, recorded on a paper writer and stored digitally for later work-up on a computer disc. No computer averaging was used. In our evaluation we measured the a- and b-wave amplitudes in the dark and light adapted state at maximum stimulus intensity and the amplitude of the 30 Hz flicker response. The normal values are given in table 1.

The VECP examinations were performed with dilated pupils. The electrodes were placed at the vertex position (Cz) and 2 cm above the inion (Oz). The ear served as reference ground. A 100 dpt contact lens gave a uniform retinal illumination. The light stimuli

Table 1 ERG amplitudes in normals and patients

Response	Normal ($\bar{x}\pm s(\mu V)$)	Patient ($\bar{x}\pm s(\mu V)$)
Dark-Adapted		
A-Wave	320±48	125±90
B-Wave	408±52	149±106
Light-Adapted		
A-Wave	113±24	60±40
B-Wave	106±26	54±35
30 Hz Flicker	136±26	24±30

Table 2 VECP amplitudes in normals and patients

Stimulus freq. (HZ)	Normal ($\bar{x}\pm s(\mu V)$)	Patient ($\bar{x}\pm s(\mu V)$)
Flash	22±8	7.7±4.5
5	17±4	6.1±3.9
10	17±5	6.1±4.1
20	8±2.5	2.8±2.7
30	6±3	1.3±2.1
40	3.2±1.5	
50	1.5±1	

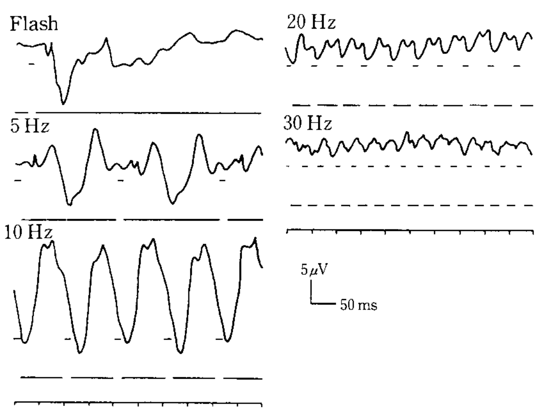

Fig. 1 Normal VECP responses to flash and flicker stimuli up to 30 Hz

were of 10 ms duration with a light intensity of 780 cd/m². First single flash stimuli were used followed by flicker stimuli with the frequencies of 5, 10, 20 and 30 Hz (Fig. 1). 64 responses were averaged with every frequency. We measured the amplitude of the flash evoked cortical potential and the implicit time of the P100-component. The amplitudes of the flicker evoked cortical potentials were determined, and we estimated the highest positive frequency response. Our normal amplitude values for flash and flicker evoked cortical potentials are shown in table 2. The high interindividual variance of the amplitudes of the flicker evoked cortical potentials results in a wide normal range. Stimulus frequencies above 30 Hz were not analyzed because the normal responses have an amplitude less than 5 μV.

Patient Data

Included in the study were patients undergoing vitrectomy between Jan 1, 1984 and Dec 31, 1989. Inclusion criteria were vitrectomy in proliferative diabetic retinopathy, proliferative vitreoretinopathy and perforating injuries. The electrophysiological examination was done in most cases within one week before surgery and not longer than 2 months before surgery. The follow-up was at least 6 months.

Exclusion criteria were no anatomical success on discharge and conditions that gave no possibility to test the visual acuity postoperatively like early retinal redetachment, severe secondary glaucoma and persistent vitreous hemorrhage. 141 patients could be included in the ERG group and 245 patients in the VECP group. ERGs were recorded in the first three years of the study. Later on they were discontinued because they appeared to be of minimal value for surgical decisions. For the evaluation of functional recovery the best postoperative visual acuity was compared to the immediate preoperative visual acuity. The x^2-test was used for statistical evaluation.

Table 3 VECP groups and postoperative mean visual acuity

Maximum frequency	n=	Mean visual acuity
Flash/5 Hz	18	0.03
10 Hz	61	0.08
20 Hz	84	0.1
30 Hz	82	0.16

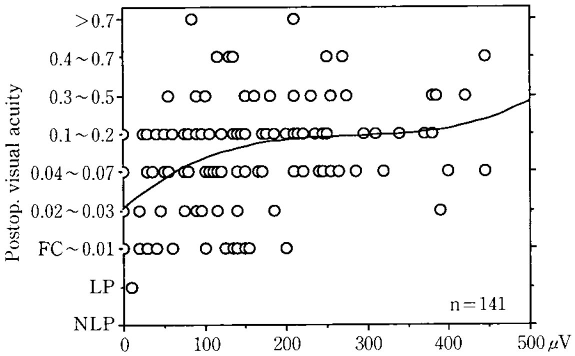

Fig. 2 B-wave amplitude at dark adaptation correlated with the best postoperative visual acuity in 8 groups. The mean visual acuity increases with higher b-wave amplitudes, but the range is very broad.
FC-Finger counting, LP-light perception or projection, NLP-no light perception

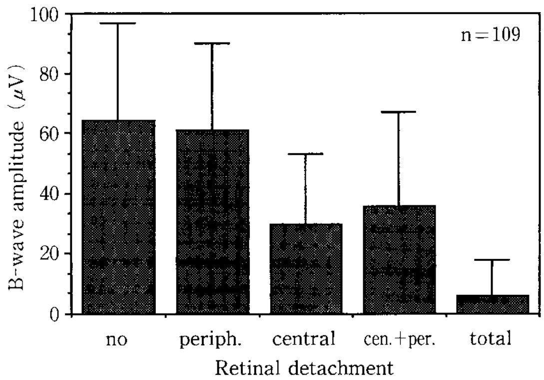

Fig. 3 B-wave amplitude at light adaptation central retinal morphology. The normal value is 106±26 μV. The b-wave amplitude is significantly more reduced when the central retina is detached and nearly unrecordable in total retinal detachment

Clinical results

Visual acuity as tested preoperatively had no predictive value for the functional outcome except in eyes with a very good preoperative visual acuity. However, in eyes with a preoperative visual acuity≦0.05 there was no correlation between the pre-and postoperative visual function.

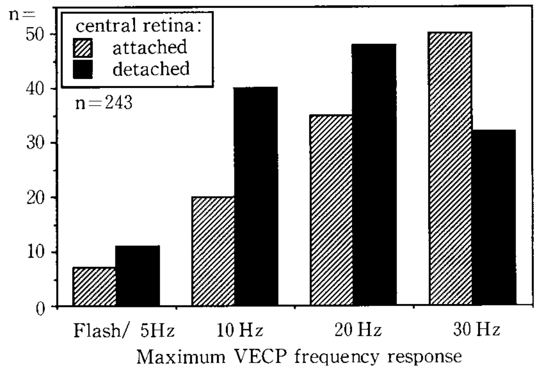

Fig. 4 Maximum flicker VECP frequency response and central retinal morphology. Patients with central retina had significantly more often a recordable 30 Hz flicker response

ERG results

In 141 eyes ERGs were recorded preoperatively. The mean visual acuity in those eyes was 0.01 and it increased to a mean postoperative visual acuity of 0.07 at the best. The amplitude values are given in table 1. The dark adapted responses were reduced to one third of the normal values and the light adapted responses to one half. The largest amplitude reduction was found in the 30 Hz flicker response. The correlation between amplitude and postoperative visual acuity is given for the b-wave under dark adaptation in figure 2. Apparently there is a correlation between ERG amplitude and postoperative visual function in this and all other tested parameters. However, the range is extremely large. Therefore, the amplitudes of all tested ERG parameters have no predictive value in a single case.

We found significant differences between eyes with attached and detached central retina in ERG amplitudes (Fig. 3). The b-wave amplitude at light adaptation was reduced to about 60% with attached central retina and severely reduced in central retinal detachment to about 30 μV. In total retinal detachment a reduction to about 10 μV was seen.

VECP results

The mean visual acuity in the 245 eyes with VECP recording was 0.02 preoperatively and 0.11 postoperatively. The amplitude values are given in table 2. The amplitudes were reduced to about one third in all recording conditions. Table 3 shows the mean visual acuity for the different groups of maximum recordable VECP frequencies. Patients who had only a response to a flash stimulus or a 5 Hz flicker stimulus, had a mean visual acuity of 0.03. With increasing maximum VECP frequency response the mean visual acuity increased up to 0.16 for eyes with a 30 Hz flicker response. Preoperatively there was no difference in visual acuity between these groups. The mean visual acuity was significantly better in eyes with a 10 Hz flicker response or higher flicker frequencies when compared to eyes with a missing 10 Hz response ($p<0.02$). Fundus visibility was good in 83 patients and was missing in 75 patients. Although patients with a good fundus visibility had a better preoperative visual acuity there was no difference between both groups in the preoperative VECP findings and the postoperative visual function. The VECP is independent of media opacities. 131 patients had a central retinal detachment, 112 patients had an attached central retina. The 30 Hz flicker response was more frequently recordable in the group with attached central retina (45%) than in the other group (24%, $p<0.01$) (Fig. 4).

Discussion

The usual preoperative functional evaluation gives no reliable data for predicting the possible postoperative function. Electrophysiologic methods allow to test the function of the retina and the transmission properties of the optic nerve objectively even in opacified media. Several investigators tried to correlate preoperative electrophysiologic findings with the postoperative functional development[1)3)5)8)~10)16)~21)]. The methods and patients examined were very variable and therefore the conclusions drawn were controversial.

Our electroretinographic findings showed a correlation with the functional properties of the retina. They depended on retinal morphology. The amplitudes were larger when the central retina was attached. The variability, however, was to large to use the ERG as a predictor of postoperative function in a single case. Algvere[1)] described in conformity with our results a high variability of the ERG. The overall small contribution of the macular retina to the ERG explains the minor value of the preoperative ERG. The morphology and function of the macular area will determine the visual acuity. After excessive pretreatment with laser-and cryocoagulation the ERG may be severly reduced[14)], but the macular area can be well preserved. On the other hand, a normal peripheral retina with a central scar or macular edema limits the recovery of visual acuity. A detached retina with a missing ERG has the potential for functional recovery after reattachment. Focal ERGs would test the macular function more appropriately, but their use is impossible in media opacities.

Many investigators used flash evoked visual cortical potentials for the examination of the optic nerve. A missing flash VECP is a contraindication for any surgical treatment[9)]. Borda[2)] and Halliday[7)] rate the flash VECP not very useful because of its large interindividual variability and normal flash VECP responses despite severe optic nerve dysfunction. Scherfig[19)~21)] found a lower postoperative visual acuity in patients with delayed latencies in the flash VECP. However, analyzing his data[19)] shows that one third of his patients with "delayed latency" had no measurable VECP at all. The majority of his successfully operated eyes with measurable VECP amplitude and delayed latency improved in visual acuity. Algvere on the other hand[1)] found no prognostic value of amplitudes or latencies of the flash VECP.

Weinstein noted the value of the different temporal stimulus properties and consequently introduced the flicker stimuli to the VECP. In small groups of patients, flicker VECPs were judged useful by Weinstein[22)] and Huber[8)]. In our series, with a measurable VECP response to a 10 Hz flicker stimulus the visual acuity is significantly better when compared to a missing 10 Hz flicker response. The difference between the higher frequencies is not convincing again due to the variability of the results. However, a 30 Hz flicker response was more frequently recordable in eyes with attached central retina.

The origin of the flicker evoked cortical potentials is not very well understood and makes it difficult to interprete them. In the peripheral retina higher flicker frequencies may be perceived than in the central retinal area. Therefore frequencies higher than 30 Hz seem not to be useful. In addition, the amplitudes at higher frequencies are very small (Table 2). The correlation between the 30 Hz flicker response and the atttached central retina shows, that the 30 Hz response is an indicator for macular function and of the transmission properties of the optic nerve. This is in contrast to the view of Fuller and Hutton[5]. They found the 10 Hz flicker response to correspond with the macular function and the 30 Hz flicker response to correspond with optic nerve function. No data are presented to support their opinion. In our experience the flicker VECP is a reliable indicator of visual function even in eyes with total retinal detachment.

Summary

The predictive value of preoperative electrophysiological examination for functional recovery after pars-plana vitrectomy was analyzed in a large, consecutive series of patients. In 141 eyes electroretinograms (ERG) were recorded. The amplitude of the a- and b-waves at dark and light adaptation and of the 30 Hz flicker response correlated with the postoperative visual acuity and the retinal morphology. However, the variability of the measured amplitudes allows no prediction of a possible recovery in a single case.

In 245 eyes flash and flicker (5, 10, 20, 30 Hz) evoked cortical potentials were recorded. A response to a 10 Hz flicker stimulus or higher frequencies indicates a significantly better functional recovery when compared to eyes with a missing 10 Hz response ($p<0.02$). More eyes with attached central retina had a 30 Hz flicker response when compared to eyes with central retinal detachment ($p<0.01$). The flicker VECP has a predictive value prior to pars plana vitrectomy.

Keywords
VECP
ERG
Vitrectomy
Preoperative functional evaluation

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術前の電気生理学的検査—経毛様体扁平部硝子体切除術々後視力の指標

要　　約

経毛様体扁平部硝子体切除術々後視機能の回復度を予想する上で，術前の電気生理学検査の意義を多数例の結果から分析した。ERG を141眼で記録した。暗順応，明順応下の a 波，b 波の振幅，および30 Hz のフリッカー反応は術後視力，および網膜の状態と関連があった。しかし，個々の症例で測定された振幅から術後視力を予測することはできなかった。

245眼で測定した単発光と 5, 10, 20, 30 Hz のフリッカーによる視覚誘発電位（VECP）から10 Hz 以上のフリッカーに対する反応が得られた症例で，反応が得られなかった症例に比し，術後視機能の回復は有意（$p<0.02$）に良好であった。眼底後極部に網膜剝離の存在していなかった眼では，黄斑部網膜が剝離していた症例に比し，30 Hz フリッカーに対する反応は高頻度で得られた（$p<0.01$）。以上より，フリッカー刺激による視覚誘発電位（VECP）は，経毛様体扁平部硝子体切除術の術後視機能を予測する術前検査として意義があるものと思われる。

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追加，本田孔士（京大）　中間透光体に混濁があれば，b 波の頂点潜時は延長する。ERG を評価する時，振幅以上に潜時の測定が大切である。