RETINAL FUNCTION AFTER SCLERAL BUCKLING FOR RECENT ONSET RHEGMATOGENOUS RETINAL DETACHMENT: ASSESSMENT WITH ELECTRORETINOGRAPHY AND OPTICAL COHERENCE TOMOGRAPHY

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ABSTRACT

Purpose: To investigate central and peripheral retinal function after scleral buckling surgery for recent onset rhegmatogenous retinal detachment (RRD).

Methods: 15 phakic patients with RRD of less than one week´s duration, were operated with scleral buckling surgery. Clinical investigation, OCT, full-field electroretinography (full-field ERG) and multifocal electroretinography (mfERG) with fundus illumination were performed preoperatively and six months postoperatively.

Results: Anatomic success was achieved in 14 patients. MfERG amplitudes were reduced preoperatively in detached retina, with significant improvement at follow-up (p=0,002). Foveal amplitudes improved significantly (p=0,027). There was no significant difference in postoperative mfERG amplitudes between areas that had been preoperatively detached or attached, respectively (p= 0,739). In the subgroup of eight patients in which the detachment engaged the fovea preoperatively, rod function improved significantly, as assessed with full-field ERG (p=0,008). In these, the extent of detachment ranged between 4-6 clock hrs, as compared to 2-5 clock hrs in the remaining patients. The OCT showed subretinal foveal fluid in four patients at follow-up.

Conclusions: In recent-onset RRD, total rod- and localized central retinal dysfunction in detached retina, can improve significantly after reattachment. MfERG and OCT are suitable tools for further studies regarding functional outcomes in retinal detachment.

Summary statement: To our knowledge, this is the first analysis of retinal structure and function, using electrophysiology, and OCT, in patients with *recent* onset retinal detachment.

Postoperative retinal function was compared with preoperative function, and final function was compared in areas that were preoperatively detached and attached, respectively.

INTRODUCTION

In retinal detachment (RD), separation of the neural retina from the retinal pigment epithelium, leads to impairment of visual function. Although the retina can be successfully reattached after one operation in most cases[1], functional changes may persist. For instance, no more than 20% and 37% of successful reattachments lead to visual acuities (VAs) of 20/50 or better, if the macula had been detached preoperatively [2,3]. Moreover, patients often complain of changes in the quality of vision, even if VA is restored.

Retinal function in RD has been studied previously with mfERG and full field ERG; function is decreased in detached retina, with improvement, after reattachment[4-9]. Full field ERG amplitudes are decreased, depending on the size and duration of detachment, with improvement after reattachment[6,7].

Studies with OCT have shown that foveal detachment, that is not detectable by ophthalmoscopy, may persist, despite successful surgery, contributing to delayed visual recovery[10,11].

In previous studies, different forms of RDs were included. As is known, RD comprises a heterogenous spectrum of clinical manifestations as to extent, type of detachment and duration.

In this study we describe functional changes in recent onset RD in phakic patients, using OCT, and full field ERG and mfERG. Perhaps particularly in this group, the outcomes of visual function might be especially affected by factors as whether the patient will be operated as soon as possible, if the macula is detached or not, and the preoperative function of the central retina. Also, for the mfERG, we had the possibility to directly vizualize the hexagonal stimulus pattern over the retina, with IR illumination, thus making it possible to determine exactly which hexagonal elements were stimulating detached and attached areas, respectively.

METHODS

Fifteen consecutive phakic patients with primary rhegmatogenous retinal detachment (RRD) of less than one weeks duration (table 1), were operated by two surgeons (KH and SA). All cases were operated with the same basic procedure; the sclera was indented with an encircling element. Where appropriate, a silicone explant was used to cover the retinal tear(s), subretinal fluid was drained by scleral incision and 0.5-1.0 ml of air was injected into the vitreous. Photocoagulation was delivered with the binocular ophthalmoscope.

Clinical investigation, OCT, full-field electroretinography (full-field ERG) and multifocal electroretinography (mfERG) were performed within 24 h preoperatively and six months postoperatively, as described previously[12]. Full-field ERG was recorded in a Nicolet analysis system (Nicolet Biomedical Instruments, Madison, WI, USA), after the pupils were dilated with topical cyclopentolate 1% and metaoxedrine 10%, and subjects were dark adaptated for 40 minutes. After topical anaesthesia of the eye, a Burian Allen bipolar contact lens was applied on the cornea and a ground electrode was applied on the forehead. Responses were obtained with a wide band filter (-3dB at 1Hz and 500 Hz) stimulating with single full field flash (30 μs) with blue light (Wratten filter #47, 47A, and 47B) and with white light (3.93 cd-s/m^2). Cone responses were obtained with 30 Hz flickering white light (0.81cd-s/m^2) averaged from 20 sweeps. The above described procedure is basically according to the standardized protocol for clinical electroretinography, ISCEV[13], with a slight modification: Recording of

30-Hz flicker cone responses was obtained without background illumination on the Ganzfield screen.

Multifocal electroretinograms were recorded using a visual evoked response imaging system (VERIS 4; EDI, San Mateo, CA, USA). After dilation of the pupils and topical anaesthesia according to above, a Burian Allen bipolar lens with IR light was applied on the ocular surface and a ground electrode on the forehead. One hundred and three stimulus hexagonal elements for recording were used. The fixation was controlled using a fundus camera and illumination with infrared light from the recording electrode, with visualization of the hexagonal elements over the retina (figure 1). P1 amplitudes and latencies in attached area, detached area, fovea (ring 1+2), and total area, were calculated as according to the guidelines for basic mfERG[14].

OCT (OCT-2 and OCT-3, Zeiss Humphrey Instruments, Dublin, CA, USA) was used to verify whether the macula was detached preoperatively, and to detect the borders between attached and detached retina. At follow-up, OCT was used to detect foveal or subfoveal fluid. The research procedures were in accordance with institutional guidelines and the Declaration of Helsinki. Approval for the study was obtained from a local ethics committee.

The Wilcoxon signed ranks test was used for statistical analysis to compare preoperative and postoperative electrophysiological data, and the Mann-Whitney U-test to compare postoperative results with a normal material for the full-field ERG and the mfERG.

RESULTS

The retina was reattached successfully after one operation in 14 cases, without any significant perioperative complications (table1). Of these, eight had foveal engagement of the detachment, preoperatively, diagnosed by OCT. A partial engagement of the fovea, was considered as “detached”. The mean age of patients was 50 years (range 26-68 years). In three patients, additional photocoagulation was delivered within one week postoperatively. One patient required further surgery subsequently, due to recurrent detachment, and was therefore not considered further.

MfERG (table 2, figure 3): Preoperatively, mfERG amplitudes in detached area were decreased, improving significantly at follow-up (p=0,002). The total mfERG area, the radius of which subtended approximately 23 degrees, improved but significance was not reached (p=0,057). Postoperative values did not differ significantly from normal (p=0,5).

Foveal (ring 1+2) amplitudes improved significantly (p=0,027), but postoperative amplitudes did not differ significantly from normal (p=0,11). Subgroup analysis revealed that the improvement of foveal amplitudes was most evident in the group of patients in which the detachment engaged the fovea preoperatively (p=0,008). Amplitudes did not improve significantly in attached retina (p=0,266), as compared to preoperatively. Final foveal amplitudes were quite similar when comparing the group of patients with detached fovea preoperatively, with the group of patients with attached fovea (p=1,000).

There was no significant difference in postoperative mfERG amplitudes between areas that had been preoperatively detached or attached, respectively, in fact these did not differ much from each other (p= 0,739, figure 4). This last comparison was calculated in ten patients in which the detachment partially engaged the area covered by the mfERG. The analysis was performed after having excluded the two innermost rings (ring 1+2), in order to adjust for the high responses in these rings, considering the fact that there were more patients in the detached macula group (table 1).

No significant changes were seen regarding implicit times.

Full-field ERG (table 2, figure 5): In the entire group of patients, total retinal response to stimulation with blue light, white light, and 30 Hz flicker implicit times, did not change significantly postoperatively, as compared to preoperatively. However, in the subgroup of patients in which the detachment engaged the fovea preoperatively, rod function was significantly improved at follow-up (p=0,008, figure 5). In this subgroup the extent of detachment ranged between 4-6 clock hrs, as compared to 2-5 clock hrs in the remaining patients which did not have foveal engagement (table 1). Cone amplitudes with 30 Hz flicker did not improve significantly (p=0,288), but when analyzing subgroups, the improvement was close to significance in the group of patients with detached fovea preoperatively (p=0,078), paralleling the results from the mfERG foveal amplitudes. Also, in this group, the improvement of the ERG single flash white light response, reflecting total retinal function, was close to significance (p=0,078). Postoperatively, all above full-field ERG amplitudes were significantly lower than normal (p<0,0005 in each case).

OCT showed subfoveal fluid in four patients at follow-up, one of whom did not have foveal detachment preoperatively.

Patient nr 9 from table 1 is shown in figures 1-2.

DISCUSSION

There are different factors contributing to loss of visual function in RRD. The immediate visual loss that occurs is likely due to altered optical properties of the detached retina, resulting in light scattering because of the irregular outer retinal surface at the level of the photoreceptors[15]. Separation of the photoreceptors from the retinal pigment epithelium disrupts the recycling of visual pigments, and separation from the choroidal vasculature leads to hypoxia. Complex cellular events, including photoreceptor outer segment degeneration, and Müller cell growth, occur, and these can to some extent be reversed with reattachment[16,17]. However, in this study and in a previous study, we have seen examples of residual subretinal foveal fluid even if the fovea was not detached preoperatively, the presence of which can contribute to delayed visual recovery[10,11]. Interestingly, in this study, these four patients with residual foveal fluid at follow-up, were among the group of five patients with the lowest postoperative foveal (ring 1+2) mfERG amplitudes (<20nV/deg^2, table 1,2). The origin of this fluid remains elusive, but it seems to be much less prevalent after vitrectomi, as compared to after scleral buckling[18].

MfERG findings similar to ours have been reported in earlier studies[4,5], where RDs of widely varying durations were examined, and fundus illumination was not used to control fixation. In this study, we only included patients with duration of detachment of no more than seven days, in order to, reduce clinical heterogeneity and confounding factors. Also, we could monitor patients´ fixation with a fundus camera and visualize the 103 hexagonal pattern on the retina during the investigation, thus making it possible to delineate exactly which areas of the central retina that were stimulated (figure 1). Borders between detached and attached areas were detected with OCT.

As shown earlier, the mfERG function improved significantly in detached area and approached significance in the total mfERG area, after successful reattachment[4,5] (figure 3). In a previous study, where long standing detachments were included and OCT was not used to determine the edge of the detachment, not only the detached retina, but also the attached retina seemed to suffer from functional loss[4]. This was not the case, however, in our study of recent onset RRD. It seems that central retinal function can remain fairly unaffected in peripheral RRD, at least for some time.

Foveal amplitudes (ring 1+2) improved significantly, most so in the group of patients with detached macula preoperatively. There was no significant difference between postoperative amplitudes between areas that had been detached and attached preoperatively, nor in foveal (ring 1+2) amplitudes, between these two groups. In fact, these did not differ much (figure 4).

Full-field ERG investigations in retinal detachment have been done previously[6,7,19], but, to our knowledge, not in a systematic way as according to the ISCEV standard. In this series, rod function was significantly improved at follow-up, in the group of patients in which the detachment engaged the fovea preoperatively, (p=0,008, figure 5). In this group, the improvement of cone responses and combined rod and cone responses, were close to significance (p=0,069, in each case). This would probably be related to the fact that patients in the detached-macula group, had a greater extent of detachment preoperatively (range 4-6 clock hrs), as compared to the macula-on group (range 2-5 clock hrs, table 1), and therefore, the gain of function could be expected to be greater, after reattachment. This is in line with the finding that the extent of the detachment correlates with the amount of preoperative amplitude reduction in the full-field ERG[7].

In a previous study, encircling buckles seemed to result in lower final ERG amplitudes, than segmental buckles[7]. Impaired blood flow through the central retinal artery, and possibly also impaired choroidal circulation, in the presence of an encircling element, are possible factors that could be associated with lack of improvement[20,21]. In our study, all above full-field ERG amplitudes differed significantly from normal, at follow-up (table 2). A difference between final postoperative ERG amplitudes has also been described earlier, between detached and fellow eyes[7].

This series cannot answer the ultimate question when to perform surgery for RD, for optimal functional outcome. However, there were no differences in functional outcomes when postoperatively comparing areas that were preoperatively attached and detached, respectively. In our experience, at least some patients with recent-onset peripheral detachments, seemed to have almost unaffected preoperative mfERG recordings. Further studies will be necessary to address this question.

In summary, we have shown that electrophysiological functional alterations occur in recent-onset retinal detachment, with significant improvements of rod function and central retinal function, after reattachment. The mfERG and OCT are suitable tools for further studies regarding central retinal function and anatomy in retinal detachment.

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FIGURE LEGENDS

Table 1: The “+” denotes involvement of detachment, and, concerning OCT findings, presence of subfoveal fluid. If the macula was partly detached preoperatively as judged with OCT, we considered this as “+”.

Table 2: Electrophysiologic data. Numbers are given as nV/deg^2 for the multifocal ERG, and as μV for the full field ERG. Normal material for the full-field ERG was based on the examination of 23 individuals (mean age 50 years, range 37-72 years), and for the mfERG on eight individuals (mean age 43 years, range 14-58 years).

Figure 1: Patient 9. The principle of monitoring fixation during mfERG, the stimulus pattern is overlaid a fundus picture, so as to correctly delineate which hexagonal elements stimulated detached and attached retina, respectively. For borderline elements, we considered these as stimulating detached area. Arrowheads point at the edge between detached and attached areas, which could only be accurately determined with OCT.

Figure 2: Patient 9 in table 1. Preoperative mfERG amplitudes as colour-coded plots, full field ERG registrations and OCT findings to the left, and corresponding postoperative findings to the right. Borders between detached and attached areas were determined with OCT.

Figure 3: Changes in the mfERG, postoperatively as compared to preoperatively, corresponding to table 2. The box-and-whiskers plots include the percentiles 25, 50 and 75. Except for outliers, the whiskers define the minimum and the maximum values.

Figure 4: Comparison of postoperative mfERG amplitudes corresponding to areas that had been preoperatively detached and attached, respectively. The box-and-whiskers plots include the percentiles 25, 50 and 75. The whiskers define the minimum and maximum values.

Figure 5: Changes in the full-field ERG in the eight patients with foveal engagement of the detachment, compared to our normal material. The box-and-whiskers plots include the percentiles 25, 50 and 75. Except for outliers, the whiskers define the minimum and the maximum values.

TABLE 1. Age, detachment charachteristics, VA and postoperative OCT findings.

Patient	Age	Extent of detachment			Duration	BCVA*		OCT follow-up
		Macular Involvement	Vascular arcade Involvement	Number of Clock hrs	Days	Preop.	Postop.	Subfoveal fluid
1	39	+	+	6	1	0,1	0,6	+
2	37	+	+	4	2	0,4	0,5	-
3	54	+	+	4	3	CF	0,6	-
4	68	-	+	4	2	0,6	1	+
5	58	-	-	2	1	0,9	0,8	-
6	55	+	+	4,5	1	0,4	0,5	+
7	30	+	+	4	7	0,3	0,4	+
8	52	+	+	6	7	0,1	0,4	-
9	45	+	+	6	7	1	1	-
10	65	-	+	3	3	0,6	†	†
11	61	-	+	5	1	0,5	0.8	-
12	60	-	+	3	7	1,0	0,8	-
13	62	-	-	3	5	1,0	1,0	-
14	26	+	+	5	6	0,05	0,6	-
15	53	-	-	3	2	1	0,8	-

detached + attached - * Best corrected VA †recurrent detachment CF=Counting Fingers

TABLE 2. Electrophysiological changes at follow-up as compared to preoperatively.

	MfERG P1 amplitudes (nV/deg2)						Full-field ERG (rods) amplitudes (µV)	
	Preop	Postop	Preop	Postop	Preop	Postop	Preop	Postop
Patient	Fovea (ring 1+2)		Total mfERG area		Detached area		Blue light	
1	4,9	19.9	4.7	15.2	3.0	15.1	63	117
2	11.2	25.8	6.5	14.7	5.6	14.4	46	72
3	9.6	28.5	6.2	14.3	3.9	12.8	39	57
4	6.6	10.8	2.5	5.7	1.2	5.2	15	37
5	26.8	25.1	13.4	17.5	*	*	44	39
6	4.6	16.9	6.6	8.0	4.1	8.8	47	61
7	16.3	19.2	8.4	11.3	5.4	12.7	115	120
8	9.0	33.9	10.4	19.4	7.8	20.5	25	58
9	15.2	58.9	9.5	28.4	6.3	29,0	96	180
11	22.9	22.1	7.3	10.3	6.8	9.0	57	120
12	†	†	†	†	*	*	50	99
13	27.7	20.0	18.0	7.0	*	*	164	93
14	12.0	16.4	8.2	9.0	4.1	9.8	67	87
15	35.9	31.8	18.7	15.3	*	*	135	72
Median	12	23.6	8.2	14.3	4.75	12.7	53.5	79.5
(range)	(4.6-35.9)	(16.4-58.9)	(2.5-18.7)	(5.7-28.4)	(1.2-7.8)	(4.8-29.0)	(15-164)	(37-180)
Normal median (range)	29.3 (22.8-35.2)		14.2 (11.0-20.0)				137 (64-221)	

* not detached in the central 45º
† could not be performed

Figure 1

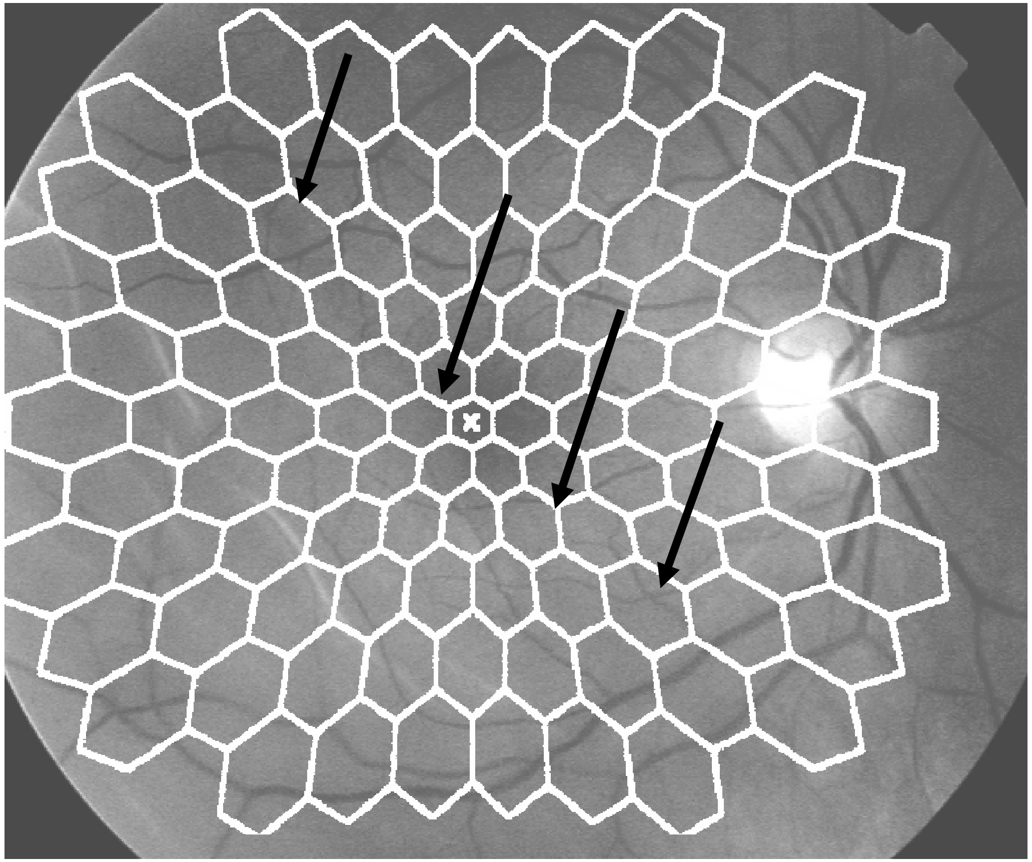
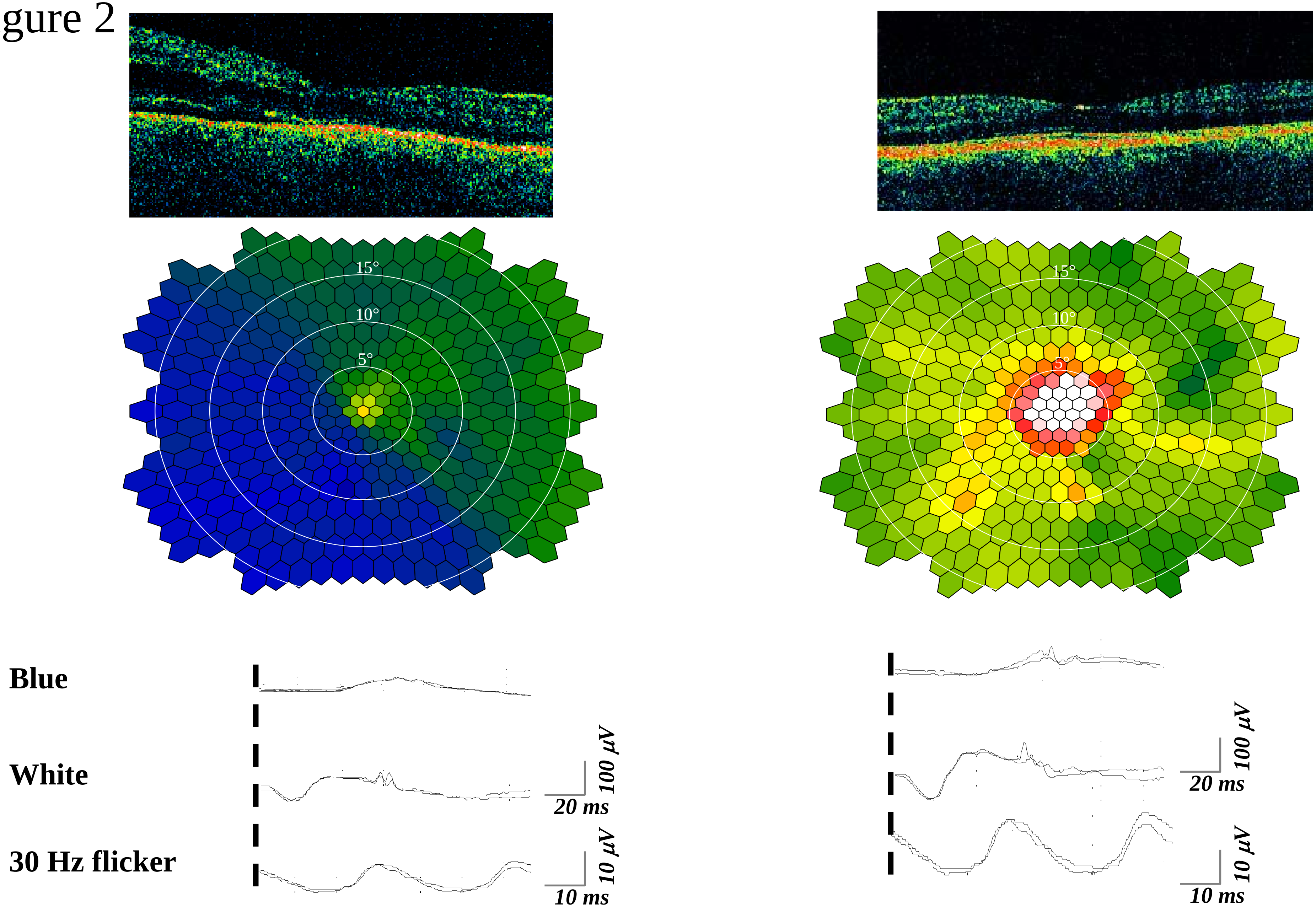


Figure 2


15°
10°
5°
15°
10°
5°
Blue
White
30 Hz flicker
100 µV
20 ms
10 µV
10 ms
100 µV
20 ms
10 µV
10 ms

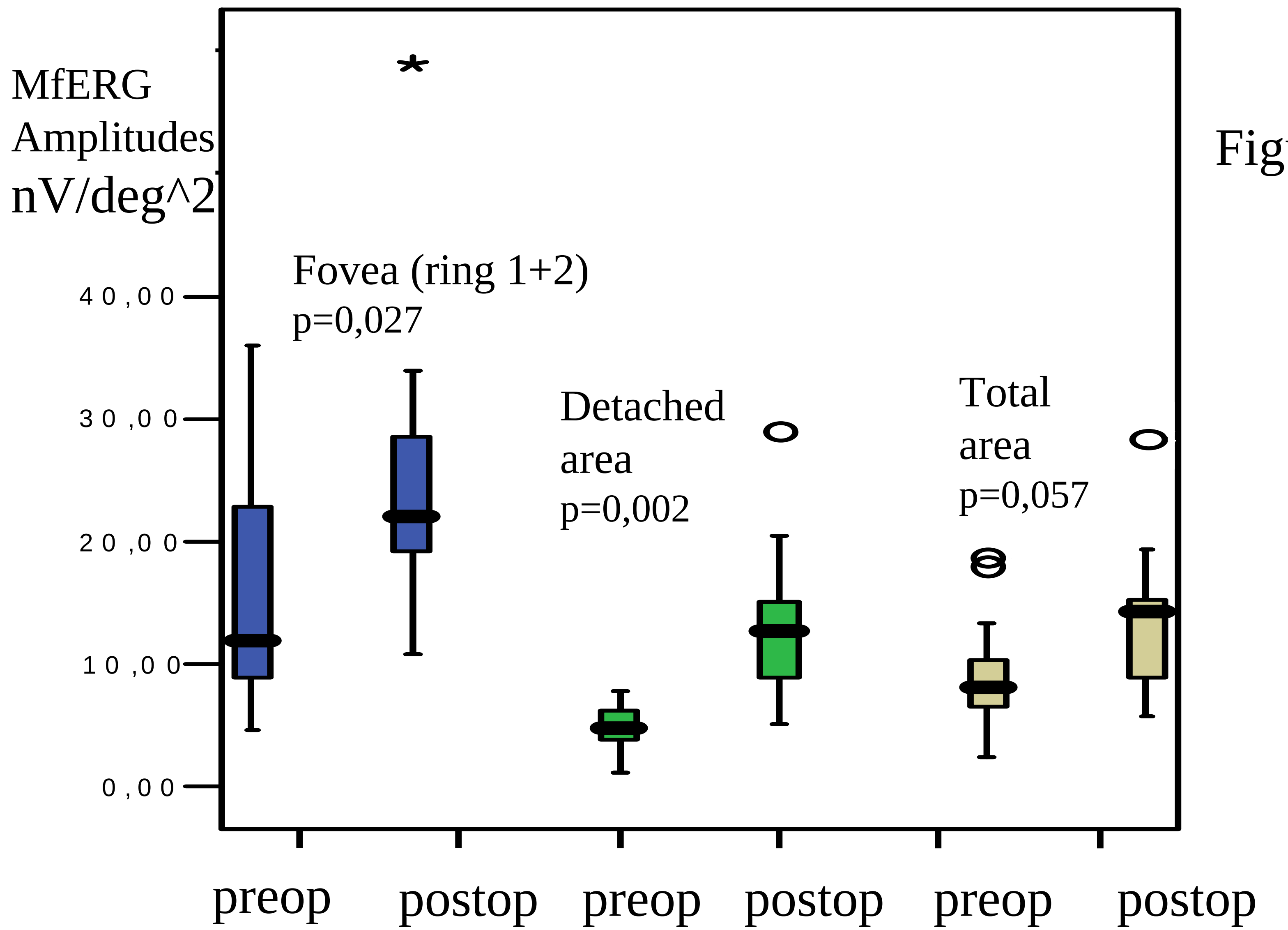

MfERG
Amplitudes
nV/deg^2
40,00
30,00
20,00
10,00
0,00
Fovea (ring 1+2)
p=0,027
Detached
area
p=0,002
Total
area
p=0,057
preop
postop
preop
postop
preop
postop

Figure 3

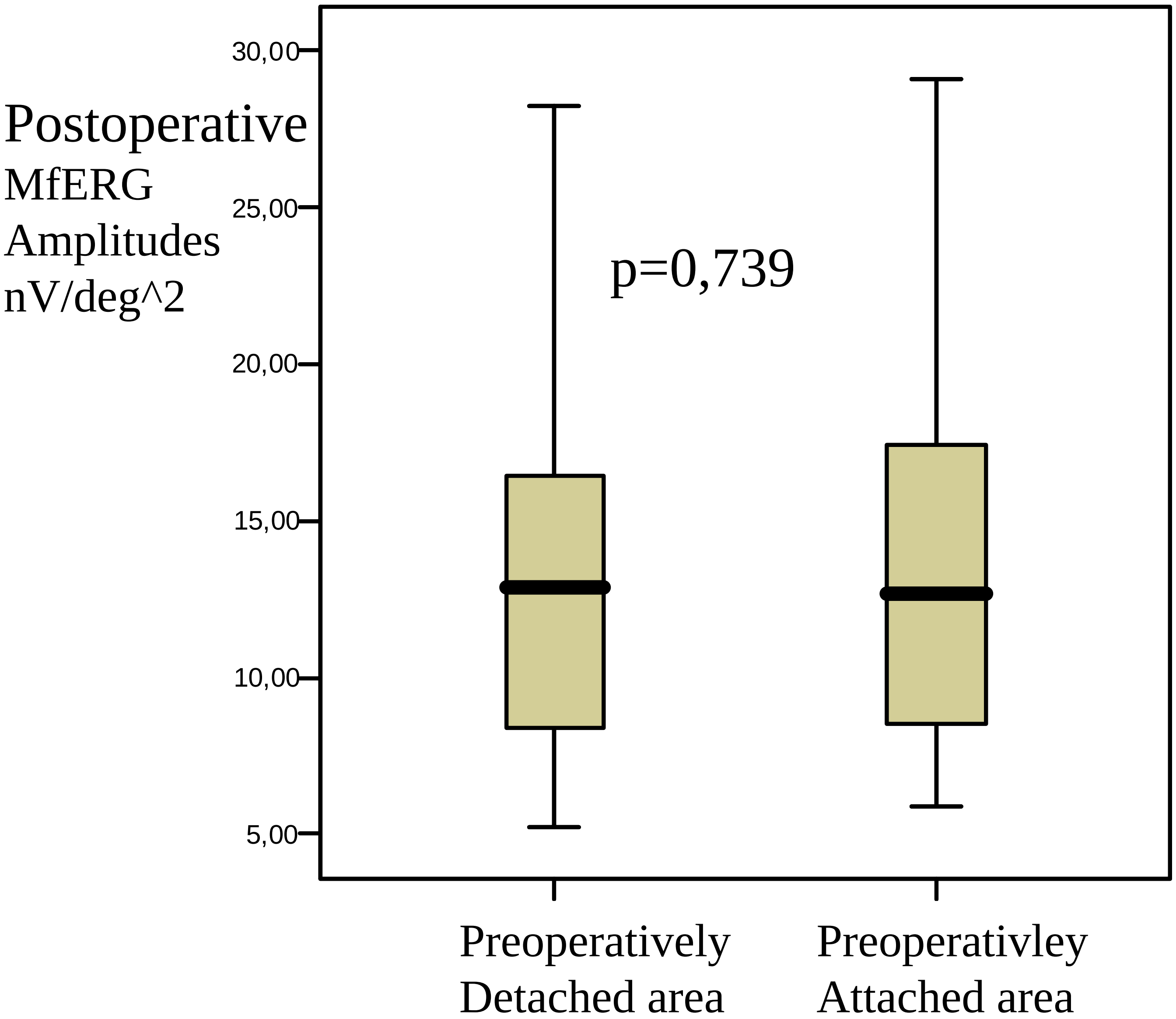

Postoperative
MfERG
Amplitudes
nV/deg^2
30,00
25,00
20,00
15,00
10,00
5,00
p=0,739
Preoperatively
Detached area
Preoperativley
Attached area

Figure 4

Rod full-field ERG amplitudes (µV) in patients with detached fovea preoperatively

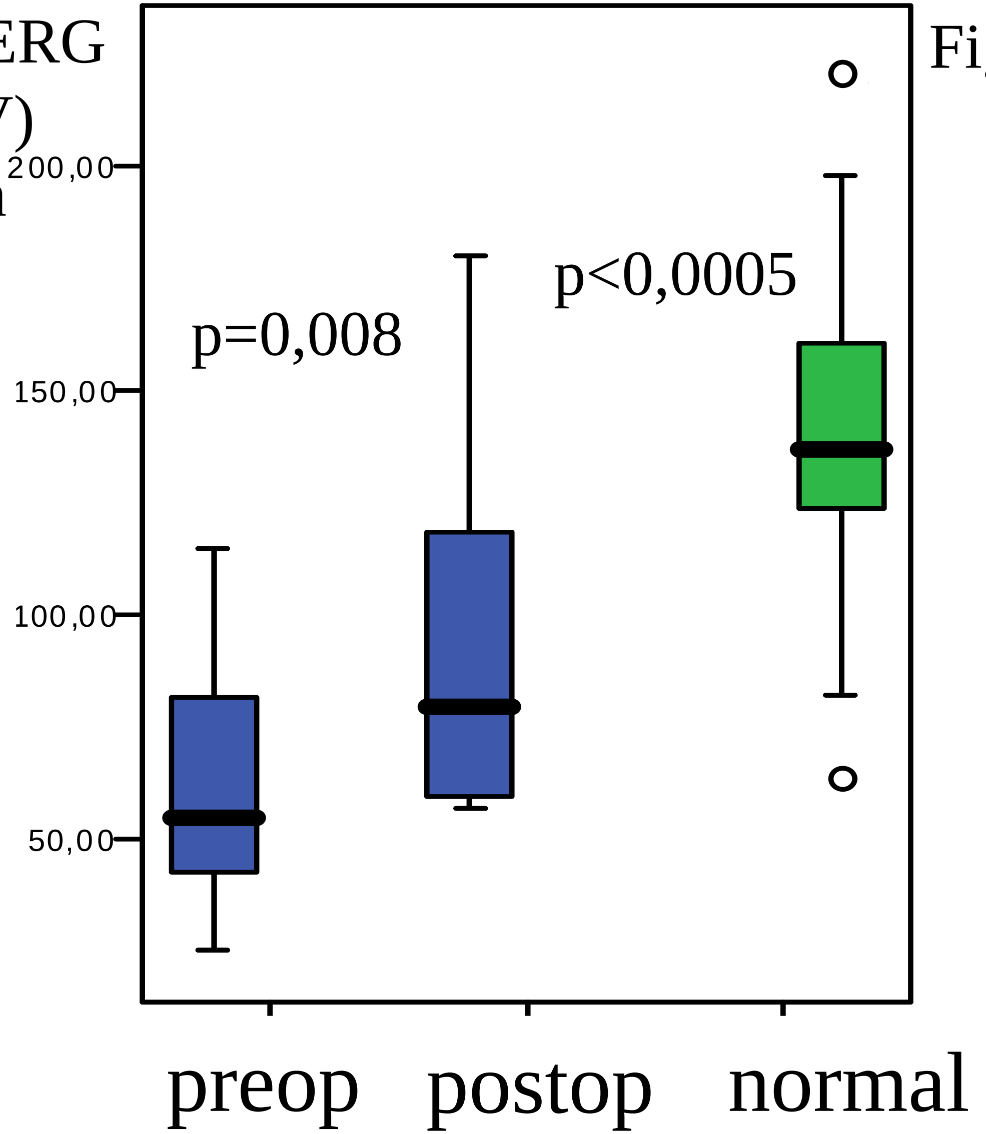


Figure 5