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Assessment of retinal nerve fiber layer thickness with NFA-GDx following successful scleral buckling surgery

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OBJECTIVE. *To assess the effect of retinal detachment (RD) on retinal nerve fiber layer (RNFL) thickness by using a scanning laser polarimeter (NFA-GDx) after successful scleral buckling surgery for the treatment of rhegmatogenous RD.*

METHODS. *Consecutive patients who had successful scleral buckling surgery in one eye were assessed for RNFL thickness by using NFA-GDx prospectively. Fellow healthy eyes of the patients formed the control group. Eyes with RD surgery were compared with the control group with respect to three variables (superior average, inferior average, and average thickness) of NFA-GDx by using two-sampled t-test. Additionally, a possible effect of duration of RD on RNFL thickness was assessed with a correlation test.*

RESULTS. *The study group consisted of 16 patients with a mean age of 49.8 years. The mean duration of RD was 28 days. Although the retardation values in operated eyes were less than that of the control eyes, the difference was not statistically significant ($p>0.05$). However, these three values were seen to increase with increased duration of detachment and this correlation was statistically significant ($R>0.5$, $p<0.03$).*

CONCLUSION. *RD seemed to cause minimal or no change in RNFL thickness as determined by GDx variables. The positive correlation between RNFL thickness and duration of RD, however, may be because of the proliferated Müller cells in eyes with RD, which may be responsible for some of the retardation measurements, which may be even more prominent in longstanding RD cases. This needs to be supported by further studies in larger patient groups with longer duration of RD and with histopathologic studies. (Eur J Ophthalmol 2003; 13: 697-701)*

KEY WORDS. *Retinal detachment, Nerve fiber layer, Scanning laser polarimeter*

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INTRODUCTION

Retinal detachment (RD), separation of the photoreceptor layer from the underlying retina pigment epithelium (RPE), causes impairment of visual function and pronounced morphologic changes. After retinal reattachment, a complex process of recovery begins, leading to partial or nearly complete restoration of vision (1). Although 90-95% of all rhegmatogenous RD can be treated successfully with one or more operations, visual results do not reflect this high anatomic success rate (2, 3). Visual acuity is mostly dependent upon the extent of damage to the macula caused by RD, which is determined mainly by the duration and extent of the detachment and postoperative macular changes (1-4).

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The scanning laser polarimeter is one of the first clinical devices for quantitative assessment of retinal nerve fiber layer (RNFL) thickness in the living human eye. When a polarized light beam passes through microtubules in the RNFL, the light is shifted from phase. The amount of phase shift is called retardation and is correlated linearly with the thickness of the RNFL (5, 6). The scanning laser polarimeter measures the amount of retardation, which probably arises from the specific arrangement of the microtubules of the retinal ganglion cell axons (7).

The effect of RD on RNFL thickness has not been determined. The current study was undertaken to identify any possible change in RNFL thickness, which may contribute to visual results following successful scleral buckling surgery, by using a scanning laser polarimeter.

PATIENTS AND METHODS

Consecutive patients with a diagnosis of unilateral rhegmatogenous RD were assessed for this prospective study. Our inclusion criteria were absence of proliferative vitreoretinopathy and successful reattachment following scleral buckling surgery. Patients with diabetes mellitus, previous history of glaucoma or any other optic nerve disease in either eye, or any retinal disease in the fellow eye were excluded from the study. Informed consent was obtained from all patients. Full ophthalmologic examination was performed preoperatively and postoperatively, including visual acuity, intraocular pressure (IOP) measurement with Goldmann applanation tonometer, fundus examination with indirect ophthalmoscopy, and Goldmann three-mirror contact lens to determine the extent and grading of RD.

The most common predisposing factors were trauma (in six cases) and degenerative myopia (in five cases). The macula was involved with the detachment in all but two cases (Tab. I). The duration of RD ranged between 3 and 120 days (mean, 28.0±34.4 days). All of the cases were operated under retrobulbar anesthesia and had circumferential scleral buckling surgery, drainage of subretinal fluid, cryotherapy, and intravitreal air injection. The central retinal artery was checked to be open at the end of surgery in all cases and none of the patients had postoperative IOP rise. Retina was successfully reattached in all cases with the first surgery.

RNFL examination was performed at least 6 months after surgery by two experienced operators (S.O., Y.L.). We measured the RNFL thickness in both eyes of the

TABLE I - PATIENT CHARACTERISTICS

Case no.	age (years)	sex	Duration of RD, days	Visual acuity		Macular detachment
				Preoperative	Postoperative	
1	48	M	7	20/25	20/40	-
2	50	M	20	HM	20/100	+
3	63	M	11	CF	20/200	+
4	50	M	15	CF	20/60	+
5	35	M	70	20/20	20/20	-
6	42	M	9	CF	20/60	+
7	72	F	10	HM	20/100	+
8	62	F	14	HM	20/60	+
9	44	M	12	HM	20/60	+
10	58	M	35	CF	20/200	+
11	29	F	7	HM	20/200	+
12	51	F	90	20/200	20/200	+
13	61	F	15	HM	20/200	+
14	42	M	120	CF	20/200	+
15	62	M	3	CF	20/30	+
16	29	F	10	CF	20/60	+

RD = Retinal detachment; HM = Hand motion; CF = Counting fingers.

patients using a scanning laser polarimeter (NFA-GDx; Laser Diagnostic Technologies, San Diego, CA), which uses a light source consisting of a near infrared diode laser (wavelength 780 nm). The field of vision was 15°. An ellipse corresponding to the rim of the optic disc was placed by the operator and the measuring ellipse at 1.75 disc diameters was generated by the machine's software. The NFA II automatically grades the quality of every image taken. Multiple images were obtained for each eye and we selected the best three images among those chosen as good quality by the machine to form the mean image, which was used for measurements. Our criteria for a good image were a sharply focused image, centrally located optic disc, and equal illumination in all segments of the image. It was more difficult to get a high-quality image from patients with pathologic myopia because of the prominent peripapillary atrophy in two of these cases; however, the circle is placed out of this atrophic area to bypass the high reflectivity of the sclera in both the operated and fellow eyes. The fellow eyes were used as a control group. All of the measurements were performed without pupil dilatation.

A symmetry analysis was then generated, which shows the right and left eyes on the same page. The printout displays 14 different variables for both eyes with comparison of retardation values with an internal normative database at the bottom. We used only superior average, inferior average, and average thickness variables, to represent NFL thickness simply. Superior (or inferior) average is average thickness of NFL along the portion of the ellipse surrounding the optic nerve in the superior (or inferior) quadrant. Average thickness is the average of all pixels outside the user-defined ellipse in the image.

The numerical values of operated eyes were compared with those of the fellow (control) eyes by using two-tailed *t*-test. The Pearson correlation test was used to investigate any possible correlation between these variables and the duration of RD.

RESULTS

Sixteen consecutive patients meeting our inclusion criteria (10 men, 6 women) with at least 6 months' follow-up were enrolled in the study. The mean follow-up period was 10.3 months (range, 6 to 18 months). The mean age of the patients was 50±12.6 years. There were 6 right and 10 left eyes in the study. Patient characteristics are given in Table I. Best-corrected visual acuity was decreased in case 1 (3 lines), unchanged in cases 5 and 12, and increased in all the others postoperatively (Tab. I). There was no macular pathology that may cause a decreased final visual acuity, such as cystoid macular edema, macular pucker, or RPE changes, in any case.

Although the means of the superior average (66.7±15.2), inferior average (74.4±12.4), and average (59.5±7.33) thickness in operated eyes were less than those of the control eyes (70.8±11.1, 76.9±16.4, and 61.6±10.1, respectively), statistical analysis of the variables revealed that the difference was not statistically significant by using two-sampled *t*-test ($p=0.13$, $p=0.27$, $p=0.47$, respectively) (Tab. II). There was, however, a statistically significant correlation between the duration of RD and these variables ($R>0.5$ and $p<0.03$ for all) (Tab. III). There was an increase in all three of these variables with increase in duration of RD.

DISCUSSION

Although success rates of retinal reattachment surgery have improved in recent decades, final visual acuity is often disappointing. In eyes with macula-off RD, only 37% achieve 20/50 or better visual acuity in spite

TABLE II - MEAN VALUES OF GDx VARIABLES IN OPERATED AND FELLOW EYES

GDx variables	Operated eyes	Fellow eyes	p value
Average thickness	59.5±7.33	61.6±10.1	0.47
Superior average	66.7±15.2	70.8±11.1	0.13
Inferior average	74.4±12.4	76.9±16.4	0.27

TABLE III - CORRELATION BETWEEN GDx VARIABLES AND DURATION OF RETINAL DETACHMENT

GDx parameter	Correlation coefficient (Pearson)	p value
Average thickness	0.701	0.002
Superior average	0.760	0.001
Inferior average	0.564	0.023

of an anatomic success rate of 90% (2). A variety of histopathologic changes occur during RD (8-10). The most prominent problem is loss of nutrition in outer segments of the retina during RD, which causes the first visible pathologic changes in outer segments of the photoreceptors; outer segments and synaptic terminals of photoreceptors degenerate as well as the photoreceptor bodies in the outer nuclear layer. The effects of RD on RPE cells are partial de-differentiation, proliferation, and migration to the subretinal area. Hypertrophy and proliferation of Müller cells also occur with RD. Longstanding RD is associated with further atrophy of the photoreceptor layer and cystic degeneration within the retina. Histopathologic studies on successfully reattached RD have shown epiretinal membrane formation in 60-76% of the cases and cystoid macular edema in 10-26% (11, 12). In a study with foveal densitometry, photopigments of foveal cone photoreceptors were seen to recover slowly after reattachment, probably because of metabolic recovery of the RPE-cone photoreceptor complex (13). The authors reported that recovery of photopigment, metamorphopsia, and color matching follow a slower time course than recovery of visual acuity, which continued to increase for 6 months after surgery. All of these changes are supposed to contribute to low functional success rates following retinal reattachment (13).

Although the effects of RD on the outer retina are well documented, there is no study on the effects of RD on the inner retinal layers. In the present study, we attempted to find possible changes in RNFL caused by RD that may contribute to low visual acuity in spite of reattachment. The operated eyes had minimally lower NFL thickness values than the fellow eyes but the difference was not statistically significant. There may be more than one process occurring, such as axon loss that causes decreased retardation and structural changes that cause increased retardation. Development of some morphologic changes caused by RD like hypertrophy and proliferation of Müller cells and epiretinal membrane formation after reattachment may affect the polarimetric measurements. Zhou and Knighton suggested that Müller cell processes are also candidates for the origin of retardation measurements in retina (7). The proliferated Müller cells in eyes with RD may be responsible for some of the retardation measurements that may cover a possible thinning of RNFL and give the wrong impression of unchanged or minimally decreased thickness of RNFL following RD surgery instead of a significant decrease in RNFL. This possible degeneration of inner retina may be even more prominent in longstanding RD cases. The present study confirms this hypothesis by demonstrating significantly higher polarimetric measurements in patients with longer duration of RD. The finding of a positive correlation between RNFL thickness and duration of RD needs to be supported by further studies in larger patient groups with longer duration of RD and with histopathologic studies. On the other hand, a possible stretching of the optic nerve during placement of encircling band and other types of trauma caused by the retinal reattachment surgery, rather than the RD itself, may be the cause of a possible thinning in RNFL and visual loss.

To our knowledge, this is the first clinical study that evaluates the effect of RD on the RNFL, and has shown that RD caused minimal or no change in RNFL thickness. However, because most of our cases have RD of short duration, further studies with larger patient groups including more patients with longstanding RD are needed to confirm the long-term effect of RD on RNFL thickness.

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