Vpliv operacije katarakte na debelino mrežnice

Influence of cataract surgery on retinal thickness

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Izvleček

Namen: *Namen raziskave je oceniti morebitni vpliv operacije katarakte na debelino mrežnice makule in sloja mrežničnih živčnih vlaken (RNFL), merjenih v različnih časovnih intervalih v obdobju enega meseca po operaciji.*

Metode: *V prospektivno študijo je bilo vključenih 27 bolnikov (27 oči), ki so bili naročeni na ambulantni poseg operacije katarakte s fakoemulzifikacijo in vstavitvijo IOL. Za meritve debeline makule, volumna makule in debeline RNFL operiranih oči smo uporabili optično koherentno tomografijo (OCT). Meritve smo izvajali pred operacijo ter 1, 14 in 30 dni po operaciji katarakte. Meritve kontralateralnega zdravega očesa so predstavljale kontrolno skupino (19 bolnikov, 19 oči).*

Rezultati: *Mesec dni po operaciji se je debelina statistično značilno pove-*

Abstract

Purpose: *We evaluated the potential influence of cataract surgery on macular thickness and on the thickness of the retinal nerve fibre layer (RNFL) at different time intervals within 1 month after surgery.*

Methods: *This prospective study involved 27 patients (27 eyes) scheduled for ambulatory cataract surgery with phacoemulsification and intraocular lens implantation. Optical coherence tomography was used to measure macular thickness, macular volume and RNFL thickness on operated eyes on the day before surgery and 1, 14 and 30 days after surgery. Contralateral non-operated eyes served as a control group (19 patients, 19 eyes).*

Results: *One month after surgery, 75% of the macula showed a significant increase in thickness ($p<0.05$).*

čala na treh četrtinah celotne površine makule ($p < 0,05$). Meritve RNFL so pokazale, da se povprečne vrednosti pri operirani skupini v primerjavi z vrednostmi pred operacijo ne povečajo ($p > 0,05$).

Zaključek: *Rezultati so potrdili vpliv operacije katarakte na debelino makule v obdobju enega meseca po operaciji.*

RNFL measurements revealed that mean values in the operated group did not increase compared with preoperative values ($p>0.05$).

Conclusion: *These results confirmed the influence of uncomplicated cataract surgery on macular thickening 1 month after surgery.*

INTRODUCTION

Every intraocular procedure (including cataract surgery) causes an immune-system response. This is the result of a biochemical cascade of events ('inflammatory response') or damage to the blood vessels and non-pigmented ciliary epithelium of the iris. In the case of intraoperative complications such as rupture of the posterior lens capsule or vitreous loss, cystoid macular oedema can occur after cataract surgery (1–3).

Advanced surgical techniques and pharmacological therapy have significantly decreased the biological response and consequently complications after cataract surgery. However, uneventful cataract surgery can lead to minor changes to the retina, such as subclinical cystoid macular oedema and retinal leakage as detected by angiography. The long-term consequences of these findings are not known (2–7).

Optical coherence tomography (OCT) is a non-contact, non-invasive and widely used tool for the diagnosis of retinal changes. It is designed to analyse retinal thickness and to reveal macular disease. The use of OCT in the postoperative period enables the detection of subclinical changes in macular thickness. Despite numerous studies, the influence of cataract surgery on macular thickness and the retinal nerve fibre layer (RNFL) has not yielded consistent results (2,3,8–10).

The goals of the present study were to: (i) evaluate the potential influence of cataract surgery on macular thickness at different times within 1 month after surgery; and (ii) measure the thickness of the RNFL after surgery at the same time intervals.

MATERIAL AND METHODS

This prospective study involved 42 patients who underwent cataract surgery in one eye at the Department of Ophthalmology in the University Clinical Centre Maribor between June and August 2010. The healthy contralateral eyes served as controls. Exclusion criteria were: age-related macular degeneration, glaucoma, diabetic retinopathy, prior intraocular surgery, ocular trauma, uveitis, and other conditions that could cause macular oedema.

Surgeries were carried out under topical anaesthesia in all cases using a standard technique by experienced surgeons. Each patient underwent standard phacoemulsification surgery followed by in-the-bag intraocular lens (IOL) implantation. The surgical technique was the same in all eyes and intraoperative complications were not observed.

Fifteen patients were lost from follow-up due to non-compliance or they missed their planned examination. Patients who attended at least two of the follow-up measurements were included in the statistic analysis. This resulted in a reduction in the number of eyes measured before surgery to 27 eyes (and 19 eyes in control group) measured 2 weeks after surgery.

All patients were informed about the procedure and gave their verbal consent.

Preoperative bilateral biometric data such as axial length, keratometry and anterior chamber depth were measured with an IOL Master Optical Biometer (Zeiss IOL Master; Carl Zeiss Meditec Ophthalmic Systems Incorporated, Dublin, CA, USA).

OCT (Zeiss Stratus OCT version 4.0.1), Carl Zeiss Meditec Ophthalmic Systems) was used for measurements of retinal thickness, retinal volume and retinal nerve fibre layer (RNFL) thickness. OCT is based on the principle of Michelson interferometry. Light passing through the eye is reflected by structures in different layers of retinal tissue. Moving the source of light over the retinal surface produces a two-dimensional cross-sectional image that resembles a histology section. The instrument electronically detects, collects, processes and stores the echo delay patterns from the retina. It displays the tomograms in real time using a false colour scale that represents the degree of light backscattering from tissues at different depths in the retina. The system stores the scans, which can be selected for later analyses (11–16).

OCT examinations were done on both eyes with the contralateral eye serving as control. Measurements were undertaken in the foveal and perifoveal area on the preoperative day (T) and on postoperative days 1 (T+1), 14 (T+14) and 30 (T+30). A 'Fast Macular Thickness Map' scan protocol was used to obtain six macular scans that were 6 mm in length and centred on the fovea equally and set 30° apart. A 'Fast RNFL Thickness' scan protocol was used to measure RNFL thickness around the macula.

Thickness values of the following macular regions were analysed: foveal minimum thickness (FM), fovea, temporal inner macula (TIM), superior inner macula (SIM), nasal inner macula (NIM), inferior inner macula (IIM), temporal outer macula (TOM), superior outer macula (SOM), nasal outer macula (NOM), and inferior outer macula (IOM).

Statistical analyses were carried out using with SPSS for Windows 17.0 (SPSS Incorporated, Chicago, IL, USA). Preoperative and postoperative measurements were compared using the paired samples t-test. Potential differences between data from the test and control group were evaluated by the independent Student's t-test. $P<0.05$ was considered significant.

RESULTS

The data analysis included the patients who took part in at least three measurements: the day before surgery, the day after surgery, 14 days after surgery and/or 30 days after surgery. This encompassed 27 patients (27 eyes) who underwent cataract surgery ('operated group') and a control group (which comprised the 19 contralateral healthy eyes of 19 patients). Participants were without any known macular disease. The mean ± SD age in the operated group was 69.07±8.74 years and was 68.89±8.86 in the control group. There was no significant difference in mean age between the two groups.

Statistically significant differences between the operated group and the control group were not observed with respect to: the mean ± SD anterior chamber depth; axial length of the eye; and the keratometric values in horizontal and vertical axis measured in dioptres and millimetres (Table 1).

Each OCT measurement provided the data for the thickness and volume of the macula. In this way, the values of FM, the thickness and volume of the fovea, average thickness and volume for each of the eight parafoveal regions (Figure 1) and RNFL were obtained.

Comparison between the operated group and the control group at the same time intervals (before surgery, 1 day after surgery, 14 days after surgery, and 30 days after surgery) showed a statistically significant difference 14 days after surgery in the nasal quarter of the macula—NIM and NOM ($p<0.05$)—and 30 days after surgery in the whole parafoveal region ($p<0.05$) (Table 2).

When comparing macular thickness on the day before surgery (T) with measurements one day after surgery (T+1), 14 days after surgery (T+14) and 30 days after surgery (T+30) in operated and control groups, there was a significant difference in the operated group in the fovea and NIM between T and T+14 and in all areas of the parafoveal region except the superior quarter between T and T+30. In the control group, a significant difference was found in the area TIM

Table 1: *Characteristics of the patient population*

	Operated group (N=27)		Control group (N=19)	
	Mean	SD	Mean	SD
Age (years)	69.07	8.74	68.89	8.86
ACD	3.10	0.38	3.07	0.35
AL	23.03	0.81	22.90	0.94
K1 (D)	42.93	1.61	43.21	1.53
K1 (mm)	7.75	0.30	7.69	0.28
K2 (D)	43.89	1.43	44.06	1.62
K2 (mm)	7.57	0.25	7.54	0.28

ACD, anterior chamber depth (mm); AL, axial length (mm); K1 + K2, keratometric values in horizontal and vertical axis in dioptres (D) and millimetres (mm).

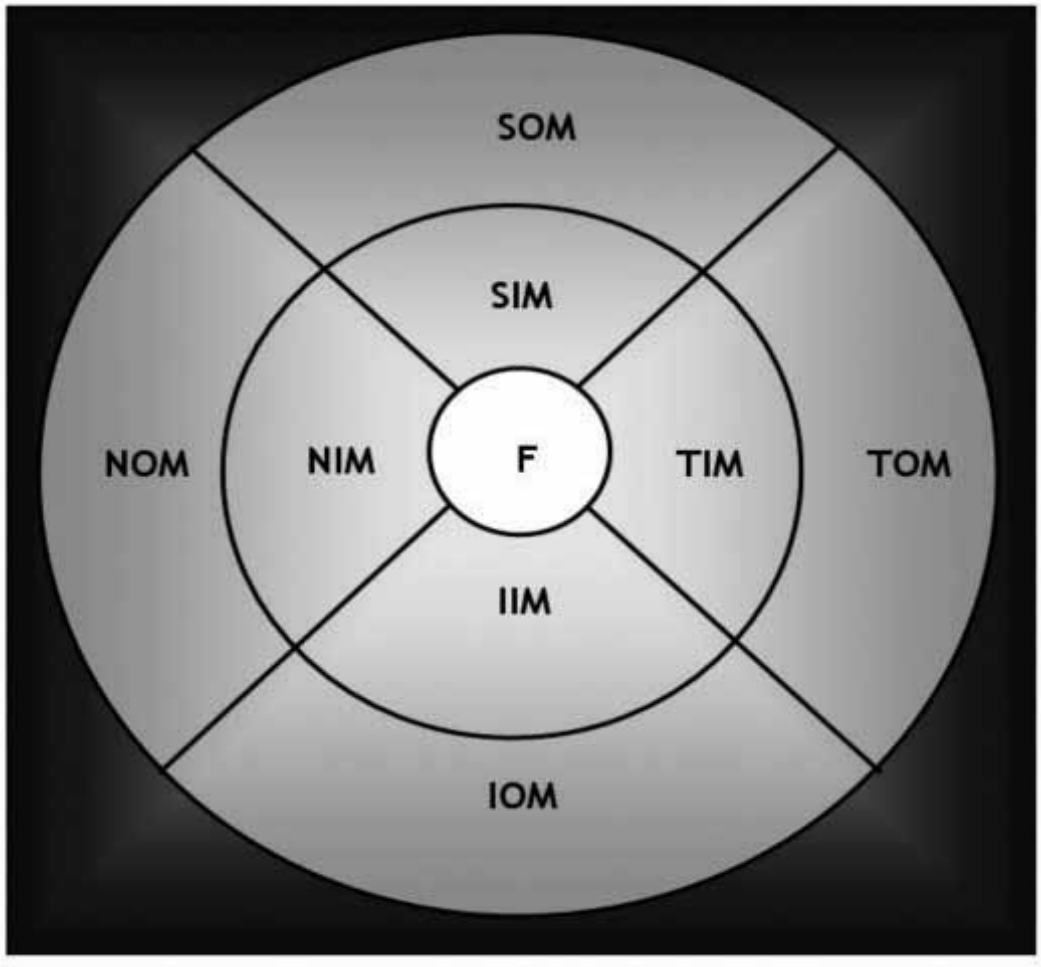

Figure 1. *Image of nine macular regions: fovea (F), temporal inner macula (TIM), superior inner macula (SIM), nasal inner macula (NIM), inferior inner macula (IIM), temporal outer macula (TOM), superior outer macula (SOM), nasal outer macula (NOM), and inferior outer macula (IOM).*

***Table 2**: Comparison of measurements of macular thickness between the operated group and the control group at identical time intervals: before surgery (T), one day after surgery (T+1), 14 days after surgery (T+14) and 30 days after surgery (T+30)*

Macular thickness (µm)		T			T+1			T+14			T+30		
Area	**Group**	**N**	**Mean ± SD**	**p**	**N**	**Mean ± SD**	**p**	**N**	**Mean ± SD**	**p**	**N**	**Mean ± SD**	**p**
FM	Operated	27	176.96±34.03	0.90	25	181.84±35.11	0.63	27	188.78±39.42	0.51	22	200.95±58.48	0.22
	Control	19	187.26±35.39		19	175.74±47.47		17	180.94±36.67		14	179.50±33.03	
F	Operated	27	206.41±26.45	0.84	25	203.36±30.32	0.84	27	216.37±27.84	0.22	22	224.91±47.75	0.23
	Control	19	204.79±25.27		19	201.42±30.30		17	205.65±28.19		14	207.93±24.12	
TIM	Operated	27	254.59±23.62	0.69	25	248.72±23.55	0.97	27	260.30±19.48	0.35	22	270.86±18.19	0.032
	Control	19	257.00±13.52		19	248.47±17.41		17	254.76±17.88		14	257.71±15.41	
SIM	Operated	27	269.26±24.06	0.76	25	260.68±22.28	0.90	27	269.67±35.17	0.44	22	280.82±20.68	0.045
	Control	19	267.37±12.85		19	261.47±19.77		17	282.82±76.50		14	267.50±15.08	
NIM	Operated	27	269.89±25.18	0.75	25	261.84±24.99	0.75	27	279.33±21.48	0.013	22	284.09±18.43	0.011
	Control	19	267.84±13.72		19	264.05±18.72		17	262.24±21.25		14	207.21±12.69	
IIM	Operated	27	263.44±25.04	0.83	25	261.60±23.01	0.85	27	271.63±28.26	0.37	22	284.23±18.13	0.008
	Control	19	264.84±16.25		19	260.37±16.76		17	264.18±22.82		14	267.07±17.07	
TOM	Operated	27	220.11±17.63	0.47	25	214.88±20.58	0.72	27	221.44±19.70	0.37	22	230.91±15.53	0.008
	Control	19	216.32±17.32		19	217.05±18.50		17	216.29±15.34		14	216.50±14.15	
SOM	Operated	27	239.52±20.81	0.26	25	228.40±22.30	0.67	27	237.15±31.45	0.52	22	244.82±15.72	0.030
	Control	19	233.00±16.13		19	230.89±16.85		17	231.71±17.88		14	233.36±13.17	
NOM	Operated	27	249.37±23.64	0.73	25	242.40±28.28	0.54	27	260.78±21.09	0.025	22	265.32±23.70	0.047
	Control	19	251.47±14.40		19	247.05±18.62		17	246.29±18.37		14	250.50±15.95	
IOM	Operated	27	226.19±15.22	0.92	25	224.60±24.24	0.78	27	235.59±24.97	0.19	22	244.77±21.51	0.003
	Control	19	226.63±15.77		19	226.68±23.37		17	226.94±10.72		14	224.64±11.70	

Foveal minimum (FM), fovea (F), temporal inner macula (TIM), superior inner macula (SIM), nasal inner macula (NIM), inferior inner macula (IIM), temporal outer macula (TOM), superior outer macula (SOM), nasal outer macula (NOM), inferior outer macula (IOM)

between measurements T and T+1 and in the area NOM between measurements T and T+14 (Table 3).

Measurements of volumes in macular regions showed a significant difference in total macular volume (TMV) between the operated group and the control group 30 days after surgery (V+30). A significant difference between the two groups was observed 14 days after surgery (V+14) in the nasal quarter of the macula (NIM, NOM) and 30 days after surgery in all parafoveal regions except the NOM. A significant difference in volumes was not observed between the operated group and the control group in the region of the fovea ($p>0.05$) (Table 4).

When comparing the volumes in the operated group, we found significant differences between measurements V and V+14 in the fovea and parafoveal region NIM, as well as between V and V+30 differences in the region of the fovea, in all parafoveal regions except the superior quarter and in TMV ($p<0.05$). The control group showed a significant difference between V

Table 3: *Comparison of macular thickness on the day before surgery (T) with measurements 1 day after surgery (T+1), 14 days after surgery (T+14) and 30 days after surgery (T+30) in operated and control groups*

Pair comparison between		T and T+1	T and T+14	T and T+30
Area	Group	p	p	p
FM	Operated	0.428	0.096	0.057
	Control	0.642	0.946	0.482
F	Operated	0.873	0.035	0.092
	Control	0.218	0.895	0.636
TIM	Operated	0.316	0.113	0.009
	Control	0.022	0.299	0.733
SIM	Operated	0.115	0.945	0.093
	Control	0.157	0.421	0.621
NIM	Operated	0.331	0.016	0.009
	Control	0.371	0.103	0.792
IIM	Operated	0.979	0.132	0.001
	Control	0.093	0.779	0.699
TOM	Operated	0.340	0.692	0.006
	Control	0.809	0.868	0.436
SOM	Operated	0.063	0.604	0.296
	Control	0.517	0.713	0.978
NOM	Operated	0.610	0.070	0.044
	Control	0.123	0.039	0.325
IOM	Operated	0.917	0.060	0.000
	Control	0.989	0.943	0.414

and V+1 in the area TIM and between measurements V and V+14 in the area NOM (Table 5).

Measured values of RNFL before surgery compared with measurements one day after surgery, 14 days after surgery, and 30 days after surgery showed no significant differences in vertical or horizontal directions in the operated group or in the control group (Table 6).

DISCUSSION

Cataract surgery has advanced greatly in recent years. Although it is a minimally invasive procedure, cataract surgery may also cause retinal damage, which could be intense (cystoid macular oedema) or minor (subclinical) and which does not affect visual acuity but which can be detected with OCT. OCT as a diagnostic method represents a completely new approach to retinal–choroidal evaluation. The method is simple, objective, non-contact, reproducible and well tolerated by patients.

Several studies in recent years have focused on macular changes after cataract surgery with OCT but consistency between the results (2,3,9,10,17–20). A related study in Turkey compared values of retinal thickness before

Table 4: *Comparison of measurements of macular volume between the operated and the control group at identical time intervals: before surgery (V), 1 day after surgery (V+1), 14 days after surgery (V+14) and 30 days after surgery (V+30)*

Volume (mm^3)		V			V+1			V+14			V+30		
Area	**Group**	**N**	**Mean ± SD**	**p**	**N**	**Mean ± SD**	**p**	**N**	**Mean ± SD**	**p**	**N**	**Mean ± SD**	**p**
FM	Operated	27	0.162±0.021	0.826	25	0.162±0.017	0.623	27	188.78±39.42	0.224	22	0.180±0.031	0.089
	Control	19	0.161±0.020		19	0.159±0.026		17	180.94±36.67		14	0.163±0.019	
F	Operated	27	0.401±0.038	0.759	25	0.391±0.037	0.950	27	216.37±27.84	0.355	22	0.426±0.029	0.034
	Control	19	0.404±0.021		19	0.391±0.027		17	205.65±28.19		14	0.405±0.024	
TIM	Operated	27	0.423±0.038	0.782	25	0.410±0.035	0.914	27	260.30±19.48	0.615	22	0.441±0.033	0.043
	Control	19	0.420±0.020		19	0.411±0.031		17	254.76±17.88		14	0.420±0.024	
SIM	Operated	27	0.424±0.039	0.766	25	0.412±0.039	0.759	27	269.67±35.17	0.010	22	0.447±0.029	0.009
	Control	19	0.421±0.021		19	0.415±0.029		17	282.82±76.50		14	0.425±0.020	
NIM	Operated	27	0.414±0.039	0.830	25	0.412±0.036	0.863	27	279.33±21.48	0.366	22	0.447±0.029	0.007
	Control	19	0.416±0.026		19	0.410±0.027		17	262.24±21.25		14	0.420±0.027	
IIM	Operated	27	1.169±0.093	0.463	25	1.141±0.109	0.719	27	271.63±28.26	0.365	22	1.226±0.082	0.008
	Control	19	1.149±0.092		19	1.153±0.098		17	264.18±22.82		14	1.150±0.076	
TOM	Operated	27	1.272±0.110	0.258	25	1.213±0.119	0.698	27	221.44±19.70	0.564	22	1.300±0.083	0.027
	Control	19	1.237±0.085		19	1.226±0.089		17	216.29±15.34		14	1.239±0.070	
SOM	Operated	27	1.324±0.126	0.726	25	1.289±0.150	0.568	27	237.15±31.45	0.020	22	1.408±0.124	0.051
	Control	19	1.336±0.077		19	1.312±0.098		17	231.71±17.88		14	1.331±0.084	
NOM	Operated	27	1.201±0.081	0.934	25	1.193±0.128	0.944	27	260.78±21.09	0.131	22	1.300±0.114	0.003
	Control	19	1.203±0.083		19	1.96±0.102		17	246.29±18.37		14	1.193±0.062	
IOM	Operated	27	6.795±0.447	0.734	25	6.628±0.545	0.744	27	235.59±24.97	0.920	22	7.182±0.432	0.003
	Control	19	6.752±0.356		19	6.677±0.399		17	226.94±10.72		14	6.750±0.326	

Total macular volume (TMV).

surgery with measurements 1 day, 1 week, 1 month, 3 and 6 months after cataract surgery and found that average retinal thickness increased with each measurement; this was in accordance with the present study ($p>0.05$). The greatest increase in retinal thickness was obtained 1 month after surgery ($p<0.05$) after a gradual decrease 3 and 6 months after surgery. Six months after surgery, macular thickness remained significantly greater than before the procedure (3).

One group of researchers compared retinal thickness at postoperative days 7, 30 and 90 with measurements from the first postoperative day. They found a significant increase in minimal retinal thickness 30 and 90 days after surgery. Foveal volume increased at the same time periods ($p<0.05$). There was also a significant increase in TMV on postoperative days 7, 30 and 90 (17). A similar study confirmed an increase in retinal thickness in the perifoveal area (3 mm and 6 mm) on days 7, 30 and 60 after cataract surgery (18).

Von Jagow, Ohrloff and Kohnen reported an increase in retinal thickness at the thinnest point of the macu-

Table 5: *Comparison of the macular volume on the day before surgery (V) with measurements 1 day after surgery (V+1), 14 days after surgery (V+14) and 30 days after surgery (V+30) in operated and control groups*

Pair comparison between		V and V+1	V and V+14	V and V+30
Area	**Group**	**p**	**p**	**p**
F	Operated	0.681	0.036	0.015
	Control	0.477	0.922	0.712
TIM	Operated	0.277	0.145	0.012
	Control	0.023	0.323	0.738
SIM	Operated	0.124	0.946	0.089
	Control	0.146	0.249	0.563
NIM	Operated	0.354	0.008	0.008
	Control	0.366	0.100	0.851
IIM	Operated	0.957	0.131	0.001
	Control	0.154	0.772	0.755
TOM	Operated	0.332	0.716	0.007
	Control	0.821	0.877	0.445
SOM	Operated	0.064	0.603	0.287
	Control	0.502	0.872	0.963
NOM	Operated	0.652	0.072	0.050
	Control	0.125	0.030	0.328
IOM	Operated	0.935	0.066	0.000
	Control	0.660	0.962	0.434
TMV	Operated	0.297	0.813	0.000
	Control	0.281	0.231	0.710

la on the first postoperative day. The same study also revealed that foveal thickness increases on the first postoperative day and remains increased 6 weeks after surgery. Von Jagow et al. and Cagini et al. did not find a correlation between the increased foveal thickness and reduced visual acuity (2,19).

One study that compared a group of patients without postoperative complications with a group that developed macular oedema after cataract surgery found an increase in macular thickness in both investigated groups 1 month after surgery (10). Another study found an increase in foveal thickness 1 week, 1 month and 3 months after cataract surgery ($p<0.05$) and a non-significant difference in foveal thickness 6 months after the procedure. However, the greatest increase in thickness of the entire macula was seen 1 month after surgery (20).

Conversely, one group of researchers encountered a significant increase in measurements of foveal thickness on the first day after surgery and a reduction to preoperative values 1 month after cataract surgery (9).

Table 6: *Measured values of RNFL before surgery compared with measurements 1 day after surgery (RNFL+1), 14 days after surgery (RNFL+14) and 30 days after surgery (RNFL+30) in operated and control groups*

Pair comparison between		RNFL and RNFL+1	RNFL and RNFL+14	RNFL and RNFL+30
Direction	Group	p	p	p
Horizontal	Operated	0.576	0.644	0.968
	Control	0.810	0.522	0.134
Vertical	Operated	0.650	0.880	1.00
	Control	0.968	0.691	0.297

Retinal fibre layer (RNFL)

We wanted to confirm the hypothesis that macular thickness increases 1 month after cataract surgery. After completing the diagnostic procedures and statistical analyses, an increase in macular thickness was found 2 weeks after cataract surgery in the macular centre-fovea and in the perifoveal region NIM ($p<0.05$). Four weeks after cataract surgery, the whole perifoveal region with the exception of the superior quarter had significantly different values compared with those on the day before surgery. When comparing macular thickness between the operated group and the control group, differences were found in measurements carried out 14 days and 30 days after the surgical procedure. A significant difference between the two groups was found in the nasal quarter of the perifoveal macula 2 weeks after cataract surgery; however, 4 weeks after surgery, it was the thickness of the whole macular region (with the exception of the fovea) that differed from preoperative values ($p<0.05$).

Another important finding was the increase in the volume of the fovea and perifoveal NIM 2 weeks after surgery in the operated group ($p<0.05$). Data analyses of the values of the same groups 1 month after cataract surgery compared with volumes before surgery showed an increase in the volume of fovea, the volume of individual perifoveal areas of the macula (TIM, NIM, IIM, TOM, NOM, IOM) and in the TMV ($p<0.05$). Comparison of volumes between two the operated group and control group revealed that the groups differed 2 weeks after surgery in the nasal macular perifoveal region (NIM and NOM) and 4 weeks after surgery in the TIM, SIM, NIM, IIM, TOM, SOM, IOM as well as TMV ($p<0.05$).

One study recently reported a statistically important increase in RNFL thickness between values measured on the first postoperative day and 1 month after cataract surgery (8). We also investigated the change in RNFL thickness after cataract surgery. Postoperative RNFL values in the operated group did not show an increase compared with preoperative values. Comparison of the average RNFL values of the control group showed a non-significant decrease of these values in follow-up measurements in horizontal and vertical directions. There was a difference between the operated group and control group with respect to RNFL thickness in horizontal and vertical directions, but this difference was significant only in the vertical direction. In the vertical direction, the average RNFL thickness in the control group was smaller compared with preoperative values in the operated group.

In conclusion, these results confirmed, in comparison with preoperative values, an increase in thickness of all macular regions 4 weeks after cataract surgery, with a non-significant increase in the fovea and superior perifoveal quarter of the macula. A longer follow-up period is necessary to determine if these changes in macular thickness after cataract surgery are temporary and reversible.

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