ORIGINAL ARTICLE

Macular thickness and volume after uncomplicated phacoemulsification surgery evaluated by optical coherence tomography. A one-year follow-up

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Abstract

OBJECTIVE: To evaluate changes in the macular thickness and volume using optical coherence tomography in patients after phacoemulsification and intracapsular implantation of a foldable intraocular lens.

MATERIALS AND METHODS: The study included 82 patients (37 males and 45 females) after phacoemulsification and intracapsular implantaion of the same type of a foldable intraocular lens, without any other eye disease. Phacoemulsification was performed with an INFINITI machine. In all patients, macular thickness and volume were measured with an optical coherence tomograph (Stratus OCT) using the Fast Macular Thickness Map. The OCT evaluation was performed on days 1, 7, 30 and 90 postoperatively. In 58 patients (71%), it was additionally performed at 12 months after surgery and in 52 patients (63%) the macular parameters in the healthy and operated eyes were compared.

RESULTS: A statistically significant increase in the minimal retinal thickness was observed on days 30 ($p<0.0005$) and 90 ($p<0.005$) postoperatively compared to post-operative day 1. A statistically significant increase in the foveal volume was seen on days 30 ($p<0.00005$) and 90 ($p<0.0005$). A statistically significant increase in the volume of the entire macula was found on days 7, 30 and 90 ($p<0.00005$).

CONCLUSION: Uncomplicated cataract phacoemulsification is followed by increases in the central retinal thickness, foveal volume and volume of the entire macula on days 30 and 90 and at 12 months postoperatively. Further observation of patients is required to confirm whether the macular parameters will return to their values on day 1 postoperatively and if so, when this will occur.

Abbreviation :

OCT	- optical coherence tomography
CMO	- cystoid macular oedema
RTA	- retinal thickness analyzer

INTRODUCTION

Nowadays phacoemulsification using ultrasound at the frequency from 27 to 60 kHz is the most commonly used method of cataract surgery, allowing rapid vision rehabilitation. Compared to intra- or extracapsular cataract extraction, this procedure is associated with lower incidence of postoperative complications, including cystoid macular oedema (CMO). CMO is mostly related to operations complicated by rupture of the posterior capsule with leakage of the vitreous body or posterior capsulotomy during the procedure. It may also follow uncomplicated cataract surgery. The etiology of CMO is unknown. Most likely it is due to increased permeability of perifoveal capillaries which may be related to generalized vascular instability and that is why it tends to occur in patients with vascular problems such as arterial hypertension and diabetes. Macular oedema revealed by the clinical examination may be confirmed by fluorescein angiography or noninvasive methods such as the retinal thickness analyzer (RTA) or optical coherence tomography (OCT). OCT is an imaging method which is especially useful in the diagnosis and management of a variety of diseases of the retina and the adjacent vitreous body (Chauhan *et al.* 1999, Massin *et al.* 2002, Massin *et al.* 2003, Soucek *et al.* 2004). Using a superluminescent diode at a wave length of 830 nm, OCT gives high-quality retinal cross-sections with an axial resolution of 10 μm, which resemble histological specimens (Puliafito *et al.* 1995; Hee *et al.* 1995). Layers of the retina are presented as bands of different colours corresponding to the differences in light reflection. The retinal pigment epithelium and choriocapilllaries form a hyperreflective band with a layer of irregular low reflectivity beneath which is the choroid.

The aim of the study was to evaluate by optical coherence tomography changes in retinal thickness and volume within the fovea in patients after phacoemulsification and intracapsular implantation of one type of a foldable intraocular lens.

MATERIAL AND METHODS

Eighty-two (82) patients (37 males, 45 females) after phacoemulsification with an intracapsular lens implantation were included in the study. Apart from the cataract, the operated eye was healthy. Patients with glaucoma, inflammatory conditions of the posterior segment of the eyeball or macular oedema of various origin were excluded from the study. All patients agreed to be in the study. Operations and examinations were performed in the Chair and Department of Ophthalmology, Medical University of Warsaw, in the period from February 2006 to November 2007. Phacoemulsification was performed with an INFINITI machine and the same type of foldable lens was implanted (AcrySoft). The retina was evaluated using an optical coherence tomograph (Zeiss Stratus OCT) on days 1, 7, 30 and 90 postoperatively. In 58 patients (71%) another examination was done 12 months after surgery. Macular volume, foveal volume and central retinal thickness were evaluated. A group of patients without any systemic disease (40 subjects, 49%) was compared to patients with hypertension and coronary heart disease (42 subjects, 51%), including 7 patients (8.5%) with diabetes, but without any signs of diabetic retinopathy. In 52% patients (63%), the macular parameters were compared in the healthy and operated eyes. The Fast Macular Thickness Map was used as the scanning strategy. Six line scans, each 6 mm in length, duration of 1.5 sec and a resolution of 10 μm, were taken. The scans were spaced at a distance of 30˚ and intersected at the fovea. The protocol of macular examination allowed a qualitative evaluation by cross-sectional scans and quantification using the retinal thickness map. The retinal thickness was determined as the distance between the internal signal from the retinal surface and the external signal from the inner margin of the band corresponding to the pigmented epithelium and choriocapillaries. Based on six line scans crossing the fovea (the fovea was at the centre of each scan) a retinal thickness map was generated, which consisted of three circles 1 mm, 3 mm and 6 mm in diameter respectively. (Figures 1a,b; 2a,b; 3a,b; 4a,b). The significance was assessed with T test (p).

RESULTS

On day 1 after surgery, there were no statistically significant differences between the macular parameters for the healthy and operated eyes (p=0.06). When subsequent OCT findings were compared with the results obtained on the first postoperative day, a statistically significant postoperative increase in the mean retinal thickness was observed for all patients on days 30 (p<0.0005, n=82) and 90 (p<0.05, n=82) and at 12 months (p<0.0005, n=58). The most significant increase was seen on day 30 after surgery and at 12 months.

A statistically significant increase in the foveal volume was seen on days 7 (p<0.05, n=82), 30 (p<0.00005, n=82) and 90 (p<0.0005, n=82) and at 12 months (p<0.00005, n=58). The most significant increase was observed on days 30 and 90.

A statistically significant increase in the volume of the entire macula was found on days 7, 30 and 90 after surgery (p<0.00005, n=82) and at 12 months (p<0.05, n=58) (Tables 1–3; Figures 5–7).

DISCUSSION

Although benefits from phacoemulsification surgery are obvious, clinicians have begun to observe the effect of the method on the macular retina. A thorough evaluation of the retina has been made possible by the use of optical coherence tomography which allows detection of trace macular oedema which is not seen on the clinical examination. There are many published reports of

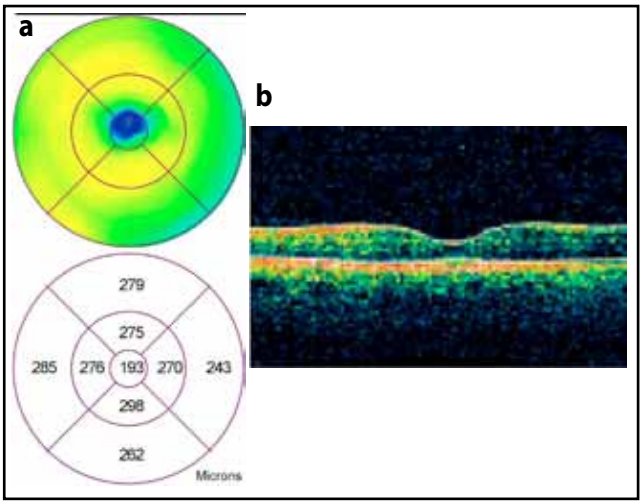

Fig.1. a: Macular thickness map on postoperative day 1.
b: OCT image on postoperative day 1

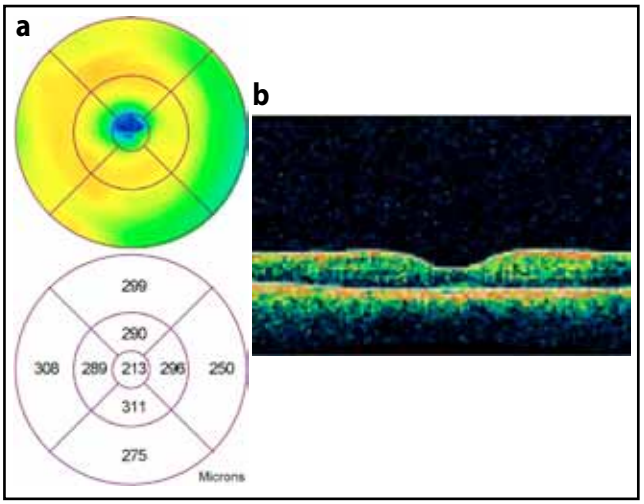

Fig. 2. a: Macular thickness map on postoperative day 7.
b: OCT image on postoperative day 7.

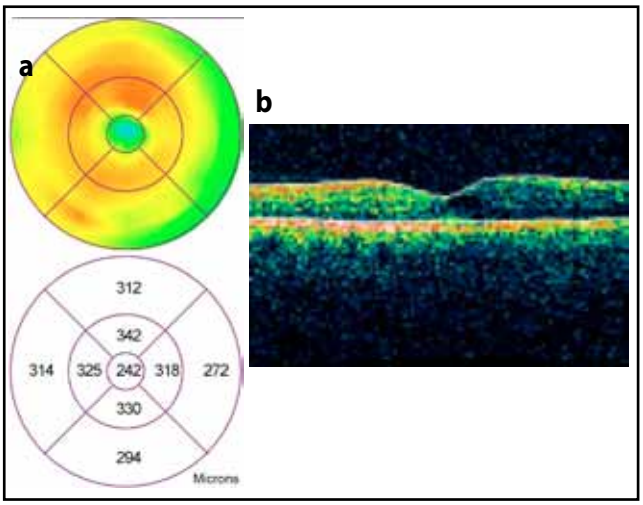

Fig. 3. a: Macular thickness map on postoperative day 30.
b: OCT image on postoperative day 30.

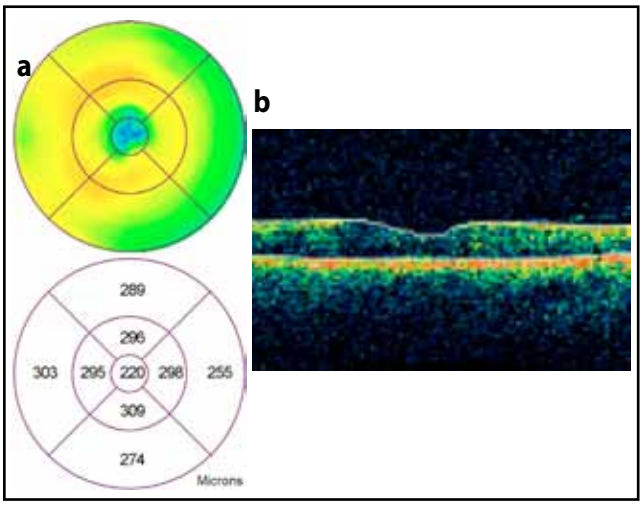

Fig. 4.a: Macular thickness map on postoperative day 90.
b: OCT image on postoperative day 90.

Tab. 1. Evaluation of the study parameters in all patients.

	Day 1 after surgery (n=82) mean±SD (median)	Day 7 after surgery (n=82) mean±SD (median)	Day 30 after surgery (n=82) mean±SD (median)	Day 90 after surgery (n=82) mean±SD (median)	12 months after surgery (n=58) mean±SD (median)
Central retinal thickness	180±31 (174)	184.9±32 (181)	191±38 (184)	188.2±38 (181)	188±34(180)
Foveal volume (in mm^3)	0.165±0.021 (0.160)	0.168±0.022 (0.164)	0.173±0.026 (0.169)	0.171±0.025 (0.166)	0.170±0.023 (0.164)
Macular volume (in mm^3)	6.808±0.52 (6.690)	6.990±0.46 (6.959)	7.057±0.59 (7.064)	7.007±0.52 (6.974)	6.945±0.47 (6.868)

Tab. 2. Evaluation of the study parameters in patients with systemic disease.

	Day 1 after surgery (n=82) mean±SD (median)	Day 7 after surgery (n=82) mean±SD (median)	Day 30 after surgery (n=82) mean±SD (median)	Day 90 after surgery (n=82) mean±SD (median)	12 months after surgery (n=58) mean±SD (median)
Central retinal thickness	186±35 (179)	190±35 (185)	198±45 (185)	194±44 (188)	193±43 (186)
Foveal volume (in mm^3)	0.169±0.022 (0.163)	0.172±0.023(0.169)	0.177±0.03(0.173)	0.175±0.028(0.173)	0.170±0.027(0.166)
Macular volume (in mm^3)	6.897±0.47 (6.744)	7.011±0.50 (6.945)	7.098±0.69 (7.228)	7.014±0.55 (7.045)	6.964±0.48 (6.890)

Tab. 3. Evaluation of the study parameters in patients in good general health.

	Day 1 after surgery (n=82) mean±SD (median)	Day 7 after surgery (n=82) mean±SD (median)	Day 30 after surgery (n=82) mean±SD (median)	Day 90 after surgery (n=82) mean±SD (median)	12 months after surgery (n=58) mean±SD (median)
Central retinal thickness	175±26 (171)	179±29 (175)	184±30 (184)	182±38.5 (176)	183±34 (179)
Foveal volume (in mm^3)	0.161±0.02 (0.157)	0.165±0.02 (0.159)	0.169±0.019 (0.167)	0.167±0.02 (0.160)	0.167±0.017 (0.162)
Macular volume (in mm^3)	6.714±0.54 (6.670)	6.968±0.41 (6.937)	7.014±0.47 (6.942)	7.000±0.48 (6.960)	6.928±0.47 (6.797)

changes in the posterior pole following phacoemulsification. The authors point out that retinal thickening at the macula may occur at any time after uncomplicated phacoemulsification. In our group of patients, the first parameter to increase, on day 7 after surgery, was the volume of the entire macula. The mean increase in the macular volume at 12 months after surgery was much lower than reported in earlier studies. Perente *et al.* (2007) studied 102 patients and described a statistically significant increase in retinal thickness on day 7 after surgery.

Other authors have found the highest increase in retinal thickness and macular volume at 4 weeks after surgery (Degenring *et al.* 2007; Jurecka *et al.* 2007a, Jurecka *et al.* 2007b). Similarly, in our study group the mean central retinal thickness, foveal volume and volume of the entire macula reached their maximum values on day 30 after surgery, although the significance coefficients varied. The parameters slowly decreased, as measured at 90 days and 12 months, but did not reach the values found on the first postoperative day.

Many authors note association between systemic disease, especially diabetes, and increased macular thickness in patients after phacoemulsification (Torrón-Fernández-Blanco *et al.* 2006; Kim *et al.* 2007). In our study, there were not many diabetic patients and they were not evaluated as a distinct group. In a group of patients with coronary heart disease and hypertension compared to healthy individuals there were no statistically significant differences in the central retinal thickness, foveal volume or volume of the entire macula on postoperative days 7, 30 and 90 and at 12 months.

In none of the patients cystoid macular oedema developed while its incidence after phacoemulsification reported in the literature ranges from 0 to 19% (Mentes *et al.* 2003; Ursell *et al.* 2000).

It seems that even uncomplicated phacoemulsification with correct implantation of an artificial lens may be followed by subclinical macular thickening and assessment of the retina by OCT should be inherent part of the postoperative evaluation of the patient.

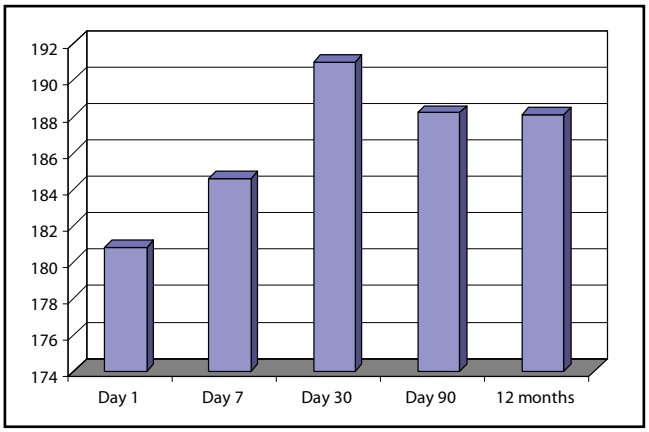

Fig. 5. Mean minimal retinal thickness in µm.

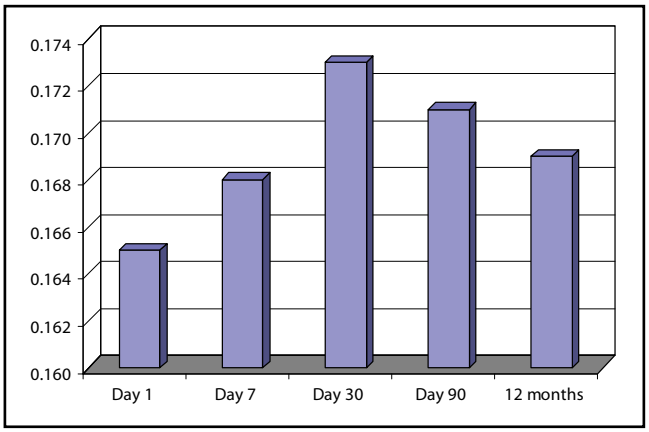

Fig. 6. Mean foveal volume in mm^3.

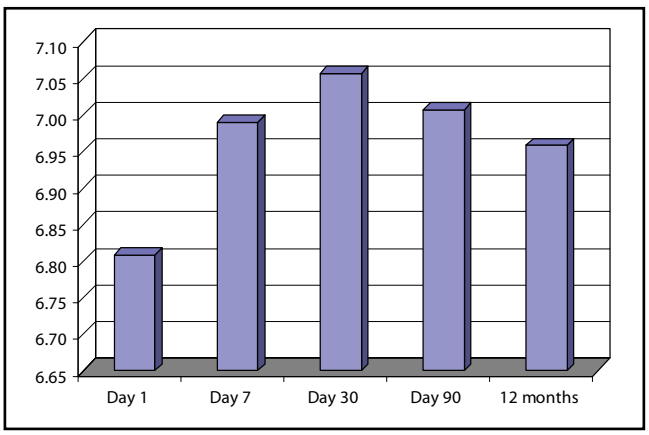

Fig. 7. Mean macular volume in mm^3.

CONCLUSION

Uncomplicated phacoemulsification is followed by increases in the central retinal thickness, volume of the fovea and volume of the entire macula on postoperative days 30 and 90 and at 12 months. Coronary heart disease and hypertension have no significant effect on these parameters.

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