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Effect of Cataract Phacoemulsification on Intraocular Pressure and Metric Parameters of the Anterior Chamber in Eyes with Angle Closure Glaucoma

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Abstract

Purpose of the study: to determine: whether, to what extent, and how permanently replacement of the patient's own lens with a thin, artificial lens during cataract phacoemulsification surgery affects the change of trabecular-iris angle configuration and the depth of the eye's anterior chamber, and in consequence, intraocular pressure in eyes with angle closure glaucoma.

Study plan: prospective study. Material and Methods: There were 86 persons in the study. Intraocular pressure (IOP), uncorrected distance visual acuity (UDVA), best corrected visual acuity (BCVA) were assessed.

Results: After PE average growth of chamber depth was 1.46 ± 0.44 mm, angle width -15.30 ± 12.40°.

Conclusions: Anterior chamber depth and trabecular-iris angle width increased significantly in all eyes after PE.

Keywords: Phacoemulsification; Intraocular pressure; Glaucoma; Anterior chamber

Introduction

A series of studies published in the literature show that anatomical changes occur in the anterior segment of the eye after cataract surgery: deepening of the chamber and widening of the trabecular-iris angle, leading to a drop in intraocular pressure [1-6]. Measurements of these parameters are conducted by means of imaging techniques such as UBM and AS-OCT. Anterior chamber depth and trabecular-iris angle width fundamentally depend on the position of the front surface of the lens and are determined by its thickness and position in the anterior eye segment. The lens grows through one's life time; however, a clouding lens, particularly with a tendency for swelling, increases its mass more than it would under normal physiological conditions, causing a change of these parameters. Furthermore, the increase of lens mass with age leads to a decrease in ligament tension and easier displacement of the lens-iris diaphragm to the front. This mechanism leads to additional reduction of the trabecular-iris angle. An operation involving the removal of a cloudy lens and its replacement with a thin, artificial intraocular lens may reverse this tendency.

Materials and Methodology

86 persons aged 73.07 ± 8.97 years participated in the prospective study. Group I consisted of 42 patients with primary trabecular-iris angle closure glaucoma (trabecular-iris angle ≤ 2° according to the Schaeffer scale in at least 3 quadrants), and Group II consisted of 44 patients without glaucoma qualified for planned phacoemulsification [7].

Medical history of previous ophthalmic treatment and surgical procedures was taken at the time of qualification. Before surgical intervention, all patients underwent a baseline examination which included determination of intraocular pressure (IOP), uncorrected distance visual acuity (UDVA), best corrected visual acuity (BCVA), and examination of the anterior and posterior segment. Cataract grading was assessed using the LOCS III scale. In addition, measurements were taken of central corneal thickness (CCT), axial length (AXL), keratometric parameters required for IOL calculation, and gonioscopy was performed. IOP was measured during the preoperative visit as a diurnal curve and on the day of surgery as a single measurement, in line with AGIS. A single measurement was taken with a Goldmann applanation tonometer on a slit-lamp biomicroscope. The reading in mmHg was rounded to the next higher integer. Each measurement was repeated, and if the two readings differed by 3 mmHg or more, a third measurement was taken. The median of the two or three measurements was the basis for determining intraocular pressure and was taken into account in the analysis. IOP was measured during the preoperative visit as a diurnal curve and on the day of surgery as a single measurement taken between 8-10 A.M. IOL was calculated on the basis of the SRK T formula. The anterior and posterior segments were evaluated for fulfillment of the examination criteria [8].

Moreover, every follow-up visit included examination with a Vu-Max I (Sonomed) ultrasound biomicroscope, during which anterior chamber depth (ACD), angle opening distance at a distance of 500 µm from the scleral spur, and trabecular-iris angle (TIA) were determined [9].

Patients were subject to observation for a period of 1 year. Once before surgery, then 3 times after surgery: in the first, sixth, and twelfth month.

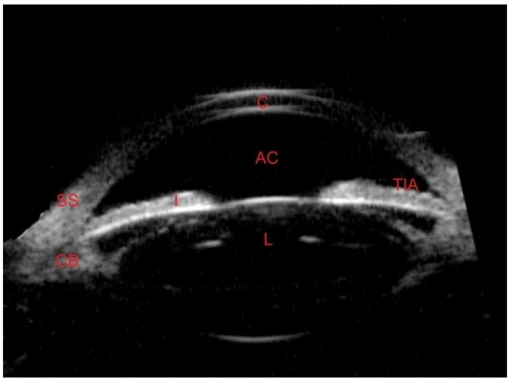

Figure 1: Structures of a correct anterior eye segment presented under UBM: C: cornea; AC: Anterior Chamber; L: lens; TIA: Trabecular-Iris Angle; CB: Ciliary Body; SS: Scleral Spur.

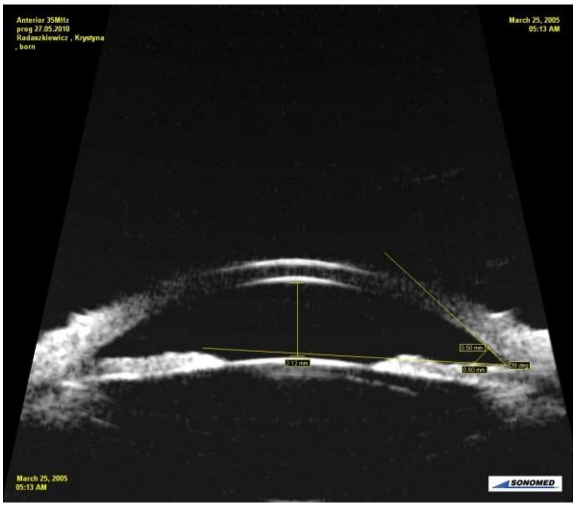

Figure 2: Method of determining anterior chamber depth and trabecular-iris angle of the anterior chamber-examination before the procedure.

Results

Anterior chamber depth (ACD) and trabecular-iris angle width (TIA, AOD) increased significantly in all eyes after PE. Initial values before PE in the group with glaucoma (I): I-ACD=1.99 ± 0.51 mm, TIA=17.26 ± 11.0°, AOD=0.24 ± 0.15 mm; without glaucoma (II)-ACD=2.52 ± 0.34 mm, TIA=32.00 ± 7.11°, AOD=0.48 ± 0.25 mm. After PE, continuous improvement of these parameters took place in all subsequent follow-up visits, and after one year, they ultimately amounted to: I–ACD=3.65 ± 0.38 mm, TIA=34.23 ± 9.74°, AOD=0.52 ± 0.17 mm; II–ACD=3.71 ± 0.59 mm, TIA=36.0 ± 8.47°, AOD=0.61 ± 0.19 mm.

Average growth of chamber depth=1.46 ± 0.44 mm, angle width=15.30 ± 12.40°. This led to a significant, permanent drop in intraocular pressure in both groups (by 3.93 ± 2.56 mmHg on average), which was greater in the group with narrow-angle glaucoma (by 4.67 ± 1.98 mmHg), making it possible to favorably reduce anti-glaucoma treatment in nearly half of all patients.

	ACD0	ACD1	ACD2	ACD3	Significance level of the test before surgery
I	1.99 ± 0.51 n=42	3.57 ± 0.48 n=42	3.64 ± 0.41 n=42	3.65 ± 0.38 n=42	p_{0-1}<0.001; p_{0-2}<0.001; p_{0-3}<0.001
II	2.52 ± 0.34 n=44	3.83 ± 0.22 n=44	4.2 ± 0.69 n=44	3.71 ± 0.59 n=44	p_{0-1}<0.001; p_{0-2}<0.001; p_{0-3}<0.001

Table 1: Compilation of all anterior chamber depth measurements (in millimeters).

Group	TIA0	TIA1	TIA2	TIA3	Significance level of the test before surgery
I	17.26 ± 11.0 n=42	33.43 ± 10.27 n=42	35.13 ± 10.64 n=42	34.23 ± 9.74 n=42	p_{0-1}<0.001; p0-2<0.001; p_{0-3}<0.001
II	32.00 ± 7.11 n=44	39.00 ± 5.66 n=44	37.50 ± 2.12 n=44	36.0 ± 8.47 n=44	p_{0-1}<0.001; p_{0-2}<0.001; p_{0-3}<0.001

Table 2: Compilation of trabecular-iris angle width measurements in the anterior chamber of the eye (in degrees).

Group	AOD0	AOD1	AOD2	AOD3	Significance level of the test before surgery
I	0.24 ± 0.15 n=42	0.48 ± 0.21 n=42	0.52 ± 0.14 n=42	0.52 ± 0.17 n=42	p_{0-1}<0.001; p_{0-2}<0.001, p_{0-3}=0.002
II	0.48 ± 0.25 n=44	0.74 ± 0.18 n=44	0.66 ± 0.09 n=44	0.61 ± 0.19 n=44	p_{0-1}<0.001; p_{0-2}<0.001, p_{0-3}=0.002

Table 3: Measurement of trabecular-iris angle opening distance in all studied groups (in millimeters).

Group	IOP0	IOP1	IOP2	IOP3	Significance level of the test before surgery
I	18.3 ± 3.78 n=42	14.25 ± 3.32 n=42	14.82 ± 2.02 n=42	13.63 ± 1.96 n=42	p_{0-1}<0.001; p_{0-2}<0.001, p_{0-3}<0.001
II	16.66 ± 4.66 n=44	13.17 ± 2.99 n=44	14.73 ± 3.10 n=44	15.33 ± 1.53 n=44	p_{0-1}=0.028

Table 4: Compilation of intraocular pressure measurements (in mmHg).

Discussion

Metric parameters of the eye's anterior chamber. Information from the literature confirmed the favorable effect of cataract removal on deepening of the anterior chamber and widening of the trabecular-iris angle that we have observed. Lens thickening, which progresses over time, plays an important role in the pathophysiology of angle closure glaucoma. It may cause displacement of the iris to the front, and the increase in lens diameter leads to a reduction of ligament tension, causing displacement of the entire lens to the front as a result [10,11]. This results in narrowing, and in extreme cases, complete closure, of the trabecular-iris angle [12].

We observed analogous changes in all eyes that we examined, however they were expressed to a greater extent in the group with angle-closure glaucoma, i.e. in eyes where lens thickness before surgery is usually the greatest - particularly in relative assessment [13].

One of the causes of deepening of the anterior chamber and widening of the trabecular-iris angle after cataract surgery is that the artificial intraocular lens is much thinner than the natural lens. Furthermore, Steuhl et al. observed displacement of the iris to the rear, deepening of the anterior chamber, and widening of the trabecular-iris angle by 9.3° on average, even in eyes with correct pressure [14]. Some authors suggest that this may cause widening or opening of intratrabecular spaces in the area of the trabecular-iris angle [15]. Simmons et al. even believe that leaving the ciliary margin and lens capsule during cataract removal with an anterior chamber implant makes it impossible for the vitreous body and iris to migrate to the front, thus preventing narrowing of the trabecular-iris angle [16]. Our studies found statistically significant deepening of the anterior chamber and widening of the trabecular-iris angle in all studied groups. Certain differences between individual groups were observed, including the fact that the most spectacular effect is achieved in the case of primary narrow-angle glaucoma, however it can generally be concluded that cataract phacoemulsification surgery has a beneficial effect on the configuration of the anterior eye segment and its implications, regardless of the coexistence of cataract and glaucoma, which seems to be of invaluable significance to the elderly. This is particularly true when one considers that even a correct, transparent lens is subject to changes unfavorable to spatial proportions in the anterior eye segment as time passes.

The observation that although studied values (ACD, AOD, TIA) in patients with narrow-angle glaucoma were significantly worse before surgery than in patients without glaucoma, both groups achieved results that were more similar to each other after surgery, also seems valuable. The evident reduction of intraocular pressure was the culmination of this. Such a spectacular result indicates that cataract removal may theoretically - and also practically - remove or significantly limit the anatomical cause of primary angle closure glaucoma [17]. Thus, it is probable that cataract surgery may completely normalize anatomical proportions and functional relations in the eye, thus equalizing intraocular pressure. Gunning and Greve found that, even in chronic angle closure with adhesions in its area, cataract removal results in the achievement of the same pressure level as in the case of classical anti-glaucoma filtration procedures [18].

Pereira et al. who studied 21 eyes without glaucoma that had undergone cataract removal surgery, obtained similar results to ours. The observation period applied by them was much shorter than the one planned in this study, however, lasting just 3 months. But the authors studied 9 parameters of the anterior eye segment: ACD, TIA, AOD 500, AOD 250, TCPD, CPSA, ILA, IZD, ICPD. In their study, average ACD value was 2.85 ± 0.40 mm before surgery and 3.73 ± 0.30 mm after surgery, meaning that it grew by 30% (+0.85 mm), while our study found this growth to be nearly 45% (+1.23 mm) in the group of healthy eyes and 65% (+1.49 mm) in eyes with glaucoma. AOD 500 before surgery amounted to 0.31 ± 0.12 mm, and an increase of this value by nearly 50%, i.e. by 0.15 mm, was observed after the procedure. TIA value increased by 10° on an average, which constituted 30% of the value from before the procedure (from 30.3 ± 6.0° to 40.05 ± 7.9°, correspondingly). In our research, AOD growth in the group of patients without glaucoma amounted to 30% (+0.11 mm) on average and 57% (+0.22 mm) in the group with glaucoma. In terms of TIA value-its growth was equal to 44% (11.41°) on average in eyes without glaucoma and 45% (+11.87) in eyes with glaucoma. The length of the observation period could have been significant here.

Kurimoto et al. in their studies involving 20 eyes, also observed a statistically significant increase in anterior chamber depth and trabecular-iris angle width, as well as an increase in angle opening distance. Moreover, they found a strong inverse correlation between values from before the procedure and the magnitude of change after the procedure. In other words, the shallower the chamber before the procedure, the more it will be deepened after the procedure, and analogously - the narrower the angle before the procedure; the most distinctly it is widened after surgery [15]. Furthermore, they observed that contact of the rear iris surface with the anterior lens capsule take place in phakic eyes. After the cataract removal procedure and intracapsular IOL implantation, the iris is freed and so such contact surface exists. This proves that the iris is pushed forward by the clouded lens and moves back after extraction of this lens, causing deepening of the anterior chamber and widening of the trabecular-iris angle. This was confirmed by the research of Pereira et al. who also measured iris displacement by means of the value of angular motion, which amounted to 10°, or precisely the amount by which TIA value grew after the procedure in their studies [19].

Opinions on the subject of the effect of cataract surgery on intraocular pressure

Despite these common problems with intraocular pressure in the early post-operative period, the clear and frequently observed pressure drop in the long-term, both after cataract phacoemulsification and after extracapsular cataract removal, is raising unfaltering interest. This problem has been the subject of many studies, although it is difficult to compare their results, mainly due to varying selection of compared groups (healthy patients, suspected glaucoma, with primary open angle glaucoma, with primary angle closure glaucoma, or patients with secondary glaucoma in the progression of PEX syndrome), as well as differing periods and systems of observation. Pressure generally decreased among patients with open angle glaucoma and remained at a nearly constant level for a period of 12-48 months after surgery. As various sources indicate, this decrease amounted to, on average: 1.4-1.9 mmHg, 1.55 mmHg, 1.88 mmHg, 2.9 mmHg, 3.1 mmHg, and 4.9-5.3 mmHg. The data obtained within the framework of this study on the subject of achieved pressure reduction in eyes after phacoemulsification falls within the upper sector of the range of pressure decrease after cataract surgeries mentioned above. The observed average pressure drop in group Ia, or patients with open angle glaucoma, amounted to 3.42 mmHg, but in group Ib-patients with narrow-angle glaucoma-it was as high as 4.67 mmHg.

Hayashi et al. describe an analogous pressure drop by 6.9 mmHg over 12 months after the procedure, as well as an even greater one, as high as 7.2 mmHg over 24 months after the procedure. Merkur et al. also presented interesting results. In their group of patients with secondary glaucoma in the progression of PEX, the average pressure decrease was even greater than in the group with open angle glaucoma (-1.88 mmHg), amounting to 2.31 mmHg.

This is somewhat concurrent with the results presented in this study, where the post-operative pressure drop in PEX-dependent glaucoma was observed at the high level of 3.49 mmHg.

In general, cataract surgery most effectively reduces intraocular pressure in angle closure glaucoma patients. Convincing explanations of this phenomenon can be found. Patients with glaucoma of this type have a more "compressed" anterior eye segment, a lens that is thicker than normal and with a more anterior position, which leads to partial pupillary block and additional angle narrowing, as well as to shallowing of the anterior chamber. This situation results in increasing obstruction of aqueous humor discharge through the trabecular-iris angle. Removal of a swollen, thickened lens restores correct anatomical conditions of the anterior eye segment, causing deepening of the anterior chamber and widening of the trabecular-iris angle, facilitating free drainage of humor through the trabeculum. A change of the position of the choroidal and corneoscleral trabeculum takes place, similarly as during parasympathomimetic therapy.

This hypothesis is also finds some practical confirmation in the results of this research. In short, the effect achieved as a result of lens replacement was not as spectacular in any of the analyzed cases as in patients with a narrowed trabecular-iris angle. This means that early cataract removal should be beneficial, particularly for patients with primary angle closure glaucoma.

The change in intraocular pressure after cataract surgery observed during the studies presented here, achieved as a result of cataract phacoemulsification surgery, was constant over time, with a tendency to stabilize. It was maintained at a similar level throughout the entire patient observation period, i.e. 1 year, generally exhibiting its lowest values after half a year of observation. When reading about similar research programs in the literature, one may come to hold the conviction that the greatest reduction of intraocular pressure takes place between the 3rd and the 6th month after the procedure. In the research of Latan et al., the most significant IOP drop took place at about the 3rd month of observation. There are reports in the literature that intraocular pressure reduction is observed even after 10 years from surgery.

Post-operative therapeutic effect

The pressure reduction achieved after cataract phacoemulsification surgery allowed for modification of anti-glaucoma treatment administered up to that point in many of our patients. In some cases, this took on the form of reducing doses of anti-glaucoma medications in eyes that were operated on, and in others-their complete elimination, when a relatively constant pattern of deviations was preserved in field of vision tests performed during every follow-up visit.

Anti-glaucoma medications were completely eliminated in 41.7% of patients from the primary angle closure glaucoma group. Reduction of medications used prior to surgery concerned 15 patients (34% of all glaucoma patients), and this can be illustrated by the following indicator: the average number of medications per patient before surgery was 1.7 and decreased to 0.22 after the procedure. To sum up, a beneficial effect was observed in a total of 25 persons, or over half of glaucoma patients. Such a result seems to be surprisingly beneficial.

In eyes with co-existing cataract and glaucoma, both our studies and studies conducted at other centers show that phacoemulsification not only improves visual acuity but also gives a long-term pressure reduction effect. In most of our patients, IOP remained constant or gradually decreased over several months. The authors already cited above achieved similar results, including Hayashi et al. They observed pressure drops significant enough to warrant cessation of anti-glaucoma treatment in 19.1% of patients from the group with open angle glaucoma and in 40.5% of patients from the group with angle closure glaucoma. Link et al. were able to achieve the same effect in 6 among the 16 studied patients, i.e. in 37%. It seems, however, that in a case where glaucoma is not stabilized and maintaining a constant low IOP is a priority-phacoemulsification cannot be an optimal or satisfactory solution by itself. In this case, trabeculectomy should be performed first and only then followed by phacoemulsification. A double-procedure operation should also be considered. In any case, the risk of transitional pressure increase should be accounted for. This risk can be minimized by the appropriate intraoperative procedures [20].

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