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THE EFFECT OF ZONULAR SUPPORT DEVICES ON INTRAOCULAR PRESSURE IN PATIENTS WITH PSEUDOEXFOLIATION GLAUCOMA

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Abstract

Objective: *to study the effect of various types of zonular support devices on intraocular pressure in patients with pseudo exfoliative glaucoma after cataract phacoemulsification.*

Material and methods: The results of surgical treatment of complicated cataract by phacoemulsification in 920 patients (1015 eyes) with pseudoexfoliation syndrome from 2015 to 2017 were analyzed. Glaucoma was detected in 137 patients (161 eyes). Zonular weakness was revealed in 82 patients (93 eyes) that were included to the study and divided into the groups. The first group consisted of 21 eyes - without capsular tension ring with isolated phakodenesis (the first stage). The second group consisted of 49 eyes using capsular tension ring. The remaining 23 eyes formed the third group, where the modified capsular tension ring with suture fixation was used.

Results: *Intraocular pressure average decreasing was detected in 21.5% and reduction of glaucoma drug use was noted in 42.8% of the baseline in the group with phakodenesis without using capsular tension ring. The intraocular pressure indices in the group with the suture fixation of the modified capsular tension ring were decreased in average in 24.2% and the number of drugs - in 37.9% in comparison with preoperative indicators. In one case was revealed pseudophacodenesis, uncontrolled intraocular pressure, that required glaucoma surgery performing. In the group with capsular tension ring implantation, was a slight decrease in intraocular pressure in 10.7% and a reducing in drugs use in 14.3% ($p \geq 0.05$), in 8 cases from 13 eyes with iridophacodenesis remained pseudophacodenesis. There was no intraocular pressure compensation that required glaucoma surgery.*

Conclusion: *Elimination of the «intraocular lens-capsular bag» complex mobility in the surgical treatment of complicated cataract in patients with pseudoexfoliation syndrome is the leading mechanism of intraocular pressure compensation. The use of a modified capsular tension ring with suture fixation affects the intraocular pressure decrease and is recommended not only to stabilize the capsular bag in lens subluxation cases, but also in iridophacodenesis in patients with glaucoma and zonular weakness. Isolated capsular tension ring use is ineffective for reducing intraocular pressure in patients with pseudoexfoliation syndrome in the presence of iridophacodenesis.*

Keywords: *pseudoexfoliative glaucoma, cataract phacoemulsification, zonular weakness, intracapsular ring, intraocular pressure.*

Introduction.

Pseudoexfoliative glaucoma (PEG) is a kind of glaucoma that forms on the background of systemic dystrophic disease - pseudoexfoliation syndrome (PES) with local pathological changes of the extracellular matrix and it is accompanied by excessive production of pathological extracellular material with its accumulation in various intra- and extraocular tissues [*Scharfenberg E, Schlötzer-Schrehardt U., 2012*].

The lens clouding (cataract) is an obligatory component of the PES, so, that it is a matrix for the exfoliative material [*Vahedian Z. et al., 2015*]. It is important, that the formation of a typical nuclear cataract in PES is combined with the lens sublux-

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ation and is also caused by pseudoexfoliation material deposition on the zinn's ligaments, followed by their damage and zonular weakness.

As a result, pathological processes are formed both in the lens zonular weakness (phacotopia) and changes associated with loss of transparency and an increase in the size of its anterior-posterior axis (phacomorphy), which subsequently affects the hypersecretion of the intraocular fluid or the outflow resistance causes the formation of the glaucoma process in these patients [*Schlötzer-Schrehardt U, 2012*].

According to the literature, the risk of open-angle glaucoma in the eyes with PES reaches 32% -55%, where the frequency of phacodenesis or lens subluxation in patients with PES varies from 8.4% to 10.6% [*Drolsum L, 2007, Govetto A et al., 2015; Kastelan S et al.,2013; You QS, 2013*].

The initial lens zonular weakness (ZW) is the main problem in cataract phacoemulsification as it increases the risk of complications. The technical difficulties in surgical treatment are related both to the presence of a rigid pupil and to the Zinn's zonule instability, that in most cases leads to the shrinking of the capsular bag or its damage during phacoemulsification or cortical masses aspiration making it difficult to implant IOL into a lens bag [*Kastelan S, 2013; Shingleton BJ et al., 2008; Malugin BE et al., 2015*].

However, zonular weakness is a more significant problem than the pupillary dilatation and increases the risk of vitreous loss during surgery in 5 times, and the posterior capsule rupture up to 27% of cases [*Kastelan S, 2013*].

The solution to this problem was the use of additional devices to perform safe adequate surgery of complicated cataracts. For the first time in 1991, posterior capsule ring-shaped support devices were used, which were placed into a bag to ensure the stability of the mobile lens when it was removed and further intraocular lens (IOL) centering [*Hara T et al., 1991*]. Polymethylmethacrylate ring was widely used in the ophthalmic surgeons practice during phaco with insignificant and moderate degrees of capsule instability, but it could not provide sufficient support in the eyes with advanced zonular weakness. In 1998, R. Cionni, R. Osher proposed the use of a modified capsular ring with additional suture fixation in the surgery of complicated cataracts with advanced lens subluxation [*Cionni RJ, Osher R, 1998*].

In the literature over the years, there have been many data on the effectiveness of this method, which was evaluated by decreasing the number of intraoperative and postoperative complications - vitreous loss, IOL decentration, which provided visual functions improvement *[Drolsum L et al., 2007; Li B. et al., 2016; Ma X., Li Z., 2014; Siddiqui SN et al., 2012; Trikha S et al., 2016*]. There is evidence of the phaco effect on intraocular pressure in healthy patients and in glaucoma ones [*Chen P et al., 2015; Poley BJ et al., 2008*].

However, there is no data of influence different capsular support devices on the hypotensive effect in the postoperative period. It was of a great interest for us to study the IOP changes in the surgical treatment of cataract with PEG with the use of different types of capsular support devices, that was the purpose of this study.

Purpose: to study the effect of various types of zonular support devices on intraocular pressure in patients with pseudoexfoliation glaucoma after cataract phacoemulsification

Material and methods

The results of surgical treatment of complicated cataract by phacoemulsification in 920 patients (1015 eyes) with pseudoexfoliation syndrome from 2015 to 2017 were analyzed. Pseudoexfoliation syndrome was established by the presence of white-gray deposits on the anterior lens capsule, on the pupillary border margin, the angle of the anterior chamber and the posterior surface of the cornea using slit lamp biomicroscopy in the conditions of maximal mydriasis. Pseudoexfoliative glaucoma (PEG) was detected in 137 patients (161 eyes) of the total number of patients.

To evaluate the effect of zonular support devices on intraocular pressure (IOP) after uneventful phacoemulsification 82 patients (93 eyes) with complicated cataract in combination with PEG were taken to the study. Exclusion criteria were eye injuries in anamnesis, previous glaucoma surgeries, laser interventions, axial size of the eye less than 21 mm and more than 24 mm, as well all cases of intraoperative complications. The patients aged from 62 to 91 years, an average of 71.4 ± 3.8 years. There were 37 men and 45 women of them. The average duration of the glau-

coma process was 2.2 ± 0.7 years.

All investigated patients received glaucoma drops in various combinations. It was assessed IOP level and the average number of used antihypertensive drugs. The criterion of the complicated cataract was zonular weakness presence, that was clinically manifested by phacodenesis and evaluated by the stages [Liu X-W. et al., 2011]. The first stage is isolated phacodenesis (48 people, 57 eyes), the second stage - phacodenesis in combination with iridodenesis (phacoiridodenesis, 26 persons, 26 eyes), the third - phacodenesis, iridodenesis and lens subluxation (8 persons, 10 eyes).

All the patients underwent phacoemulsification through a 2.75 *mm* corneal incision, using intracameral anesthesia. For the prevention of intraoperative complications and stabilization of the capsular bag, a standard polymethylmethacrylate capsular tension ring (CTR) with a diameter of 13 *mm* or a modified capsule ring of the Cionni type with a suture fixation to the sclera in 2 mm from the limbus by 10.0 prolene was used. All surgeries were performed without intraoperative complications.

Taking into account the purpose of our study, all the patients were retrospectively divided into the groups, depending on the type of zonular support. The first group consisted of 21 eyes with isolated phacodenesis (the first stage) - without CTR use. The second group consisted of 49 eyes with CTR use, 36 of them with isolated phacodenesis (the 1st stage) and 13 eyes with phacoiridodenesis (2nd stage). The remaining 23 eyes made up the third observation group, where a modified CTR with a suture fixation was used, among them 13 eyes were of the 2nd stage and 10 eyes were of the 3d stage with lens subluxation.

Dynamic monitoring of the patients was carried out in the early postoperative period in 1, 3, 6 and 12 months. In order to exclude reactive hypertension and the final selection number of glaucoma drops, the efficacy of the surgery was evaluated at the maximum observation periods of 12 months.

Statistical processing of the study's results was carried out by calculating the arithmetic mean (M), the error of the arithmetic mean (m), and represented as M ± m. Differences between the groups were assessed using the Student's test, the results were considered reliable at P value of 0.05 or less.

RESULTS

To evaluate the change of IOP level after the cataract surgery with different types of devices for capsular support in zonular weakness initial level of IOP was studied (Table 1).

TABLE 1.

Characteristics of IOP level, depending on zonular weakness stage

IOP level, *(mm Hg)*	Zonular weakness stage, n					
	1		2		3	
	Eyes	%	Eyes	%	Eyes	%
14-19	12	21.1				
20-24	45	78.9	10	38.5		
25-30			11	42.3	7	70.0
30-35			5	19.2	3	30.0
Total	57	100	26	100	10	100

As can be seen from the presented table, in the patients with the 1st stage of zonular weakness, IOP compensation is noted in 100% of cases, with the average number of used antihypertensive drops have been 1.3 ± 0.06. In the second stage of zonular weakness, only 38.5% (10 eyes) have showed normal IOP, but with an average increase of 2.2 ± 0.08 of the number of hypotensive drops. IOP level was remained uncompensated (28.1 ± 2.1 *mm Hg*) in 61.5% of cases (16 eyes), the average number of the used drops was 2.9 ± 0.16. At the same time, in all the patients with lens subluxation (the third stage) the maximum number of hypotensive drops was 3.0 ± 0.13, the average IOP value remained uncompensated and was 29.6 ± 2.4 *mm Hg*.

Thus, the degree of lens mobility determines the IOP level compensation and the resistance to the medical hypotensive therapy that is used, which makes it necessary to perform surgical treatment.

Taking into account that the phacoemulsification of complicated cataract in the patients with PEG was carried out to renewal clarity of the eye optical system, the distribution of patients was conducted depending on the type of zonular support devices with the use of different CTR to prevent intraoperative complications, without reference to IOP baseline level. Thus, in the analysis of surgical treatment, all eyes with isolated phacodenesis (the first stage) consisted the first group of observations. The second group consisted of 36 eyes

with isolated phacodenesis (the 1st tage) and 13 eyes with phacoiridodenesis (the 2nd stage). The third group included 13 eyes of the 2nd stage and 10 eyes – the 3d stage.

Thus, in patients with the 1st stage of zonular weakness in 36.8% of cases (21 eyes), surgical treatment of complicated cataract was performed without CTR use, and in 63.2% (36 eyes) of cases were used CTR to stabilize the capsular bag. CTR was used for stabilization of all the patients with the 2d stage of zonular weakness, but in 50% of cases (13 eyes) suture fixation of the modified CTR was applied. In the third stage of zonular weakness in 100% of cases (10 eyes), a modified CTR with suture fixation was practiced. Table 2 shows IOP and number of glaucoma medication change after phaco surgery.

As can be seen from the presented table, in patients of the 1st group there was an average decrease in IOP on 21.5% of the baseline, with a decrease in the number of drops in 42.8 %. IOP was decreased in the third group on 24.2% and, consequently, the number of hypotensive drops was decreased in 37.9 %. However, in the second observation group there was a tendency to a slight decrease of IOP in 10.7 % and antihypertensive drops use was reduced in 14.3%, which is unreliable in comparison with initial data.

Table 2.

IOP and glaucoma medication changes in patients with pseudoexfoliative glaucoma after cataract surgery (M ± m).

Parameter		Group		
		Without capsular support devices n=21	CTR n=49	CTR and suture fixation n=23
Preoperative IOP		21.4±2.2	25.1±2.1	28.1±1.9
Postoperative IOP in 12 months		16.8±1.6	22.4±1.8	21.3±1.1
P		0.05	0.02	0.005
IOP change	*mm Hg.*	4.6	2.7	6.8
	%	21.5	10.7	24.2
n preoperative medication		1.4±0.02	2.8±1.10	2.9±0.51
n postoperative medication		0.8±0.04	2.4±0.18	1.8±0.09
P		0.001	0.1	0.05
Medication change%		42.8	14.3	37.9
Glaucoma surgery		0	8	1

So, the reduction of IOP was revealed in the patients without additional zonular support and in cases with suture fixation of the modified CTR. In the second observation group, with CTR implantation an additional glaucoma surgery was required in 16 % of cases (8 eyes) in the postoperative period in order to reduce IOP, while in the third group, in spite of the presence of the initial lens subluxation - only in 4% of cases (1 eye).

Discussion:

The results of the conducted study have convincingly demonstrated that the use of CTR at various stages of the zonular weakness allows to avoid intraoperative complications and to perform capsular IOL implantation with good centralization. The obtained data are agreed with the opinion of other authors [*Cionni R.J., Osher R., 1998, Li B.et al., 2016*]. At the same time, we noted a positive moment in the CTR use for the elimination of phacodenesis (the 1st stage of zonular weakness) in the postoperative period in 36 patients of the second group. These observations were also noted in the works of Siddiqui SN, Shaikh ZA, Khan A., 2012 and Trikha S.et al., 2016.

At the same time, we found that in 26 patients with initial iridophacodenesis (the 2nd stage of zonular weakness), the results of using zonular support devices were various and depended on the type of CTR. In 50% of cases (13 eyes) with isolated CTR use in the postoperative period, pseudoiridodenesis was persisted, in the remaining patients (13 eyes), the suture fixation of the modified CTR has ensured the complete stability of the "IOL capsule bag" complex.

The use of a modified ring in the patients with lens subluxation (the 3d stage of zonular weakness) also has been showed a high efficacy in 90% of cases (9 eyes) and only in one eye (10%) pseudoiridodenesis was remained. The received data mark the novelty of our study.

In whole in all the studied groups, there

was a tendency for IOP decrease relatively to its preoperative level, in 12 months after cataract phacoemulsification which is described in many works devoted to the positive effect of cataract phacoemulsification on the level of ophthalmotonus [*Poley B.J., Lindstrom R. L., Samuelson T.W, 2008, Shingleton B.J. et al., 2008, Rasin O.G., 2012, Jimenez-Roman J. et al., 2015*]. According to our data, in the patients with moderate and severe zonular weakness, a large effect on the IOP level has the used device for capsular bag support. The elimination of the mobility of "IOL capsular bag" complex is one of the favorable mechanisms for IOL compensating, while Kim M. and co-author, (2012) indicate that the lead in IOP compensation after phacoemulsification has an increase the depth of the anterior chamber and the degree of its angle opening.

Thus, we came to the conclusion that in the patients with PEG and different degrees of zonular weakness, the use of modified CTR with suture fixation affects the IOP decrease and is shown not only to stabilize the capsular bag in cases of lens subluxation but also in cases of iridophacodenesis. Isolated CTR application is ineffective for IOP reducing in the patients with PEG in the presence of iridophacodenesis.

Some authors have reported a decrease in the number and / or dose of drugs after phacoemulsification in more than half of the patients with complicated cataract and open-angle glaucoma in the background of PES [*Chen P.et al., 2015, Jimenez-Roman J. et al., 2017*], while others do not show a significant difference in the hypotensive regime [*Kim M. et al., 2012*]. According to the results of our own study, the average reduction in medical therapy was 43%, 15% and 38%, respectively, in the three observation groups. However, in the analysis of each individual case, in 8 patients (16 %) of the 2nd observation group and one patient (4%) of the third group with pseudoiridodenesis in the postoperative period, the number of antihypertensive drugs has increased to the maximum possible, and subsequently to the glaucoma surgery performing.

The aim of this research has been achieved in that respect that we have studied the effect of the type of zonular support device in the phacoemulsification of complicated cataract in the patients with PEG at the IOP level in the postoperative period and it is showed the need for a differential approach to the choice of the type of CTR due to the zonular weakness stage. However, it is expediently to determine surgical tactics in future work in the absence of IOP compensation and to detect the indications for simultaneous glaucoma surgeries in the patients with PEG on the background of complicated cataract.

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