

## ZONULAR INSTABILITY IN PATIENTS WITH PSEUDOEXFOLIATIVE SYNDROME: ANALYSIS OF 1000 CONSECUTIVE PHACOEMULSIFICATIONS

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✧ Phacoemulsification (PHACO) is the gold standard of cataract surgery. Cataract surgery in eyes with pseudoexfoliative (PEX) syndrome is associated with increased risk of intra- and postoperative complications. Zonular laxity is one of the main causes of surgical complications. **Purpose.** To assess the degree of zonular weakness in patients with PEX. **Materials and methods.** 1010 eyes (580 eyes with PEX and 430 eyes without it) that underwent consecutive PHACO at the Ophthalmology Department No 5 of the City Multifunctional Hospital No 2 from May 2016 until October 2017 were enrolled in the study. The zonular laxity was assessed preoperatively and intraoperatively. **Results.** Zonular weakness was observed more often in patients with PEX, both at preoperative and intraoperative evaluation ( $p < 0.05$ ). However, in both groups, the percentage of zonular weakness estimated intraoperatively, was several times higher, than that estimated preoperatively. Nevertheless there was no difference in the rate of capsular bag related intraoperative complications between two groups.

✧ **Keywords:** phacoemulsification; pseudoexfoliation syndrome; zonular laxity; lens subluxation.

## НЕСТАБИЛЬНОСТЬ СВЯЗОЧНОГО АППАРАТА ХРУСТАЛИКА У ПАЦИЕНТОВ С ПСЕВДОЭКЗОФОЛИАТИВНЫМ СИНДРОМОМ: АНАЛИЗ 1000 ПОСЛЕДОВАТЕЛЬНЫХ ФАКОЭМУЛЬСИФИКАЦИЙ

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✧ Факоэмульсификация (ФЭ) является «золотым стандартом» хирургии катаракты. Наличие псевдоэкзофолиативного синдрома (ПЭС) влечёт за собой повышенный риск как интра-, так и послеоперационных осложнений. Одной из основных причин интраоперационных осложнений является слабость связочного аппарата хрусталика. **Цель** — оценить степень слабости цинновых связок у пациентов с ПЭС. **Материалы и методы.** В рамках исследования на базе отделения офтальмологии № V ГМПБ № 2 с мая 2016 по октябрь 2017 г. были обследованы все 1010 глаз (580 глаз с ПЭС и 430 глаз без ПЭС), на которых выполнялась ФЭ по поводу возрастной катаракты. Слабость связочного аппарата оценивалась дооперационно и интраоперационно. **Результаты.** Слабость связочного аппарата хрусталика наблюдалась чаще у пациентов с ПЭС как при дооперационной, так и при интраоперационной оценке ( $p < 0,05$ ). Однако в обеих группах процент слабости связочного аппарата, оцениваемый интраоперационно, в не-

сколько раз выше определяемого дооперационно. Тем не менее процент интраоперационных осложнений, связанных с капсульным мешком, достоверно не отличался в двух группах.

✦ **Ключевые слова:** факоэмульсификация; псевдоэкзофолиативный синдром; слабость связочного аппарата хрусталика; подвывих хрусталика.

## INTRODUCTION

Cataracts remain the leading cause of reversible blindness worldwide [3]. Currently, phacoemulsification (PE) is considered the gold standard for cataract surgery [3, 5, 9]. The main risk factor for cataracts is age; however, pseudoexfoliation syndrome (PES) can trigger sclerotic changes in the lens nucleus [7, 12].

PES is an age-related systemic disease characterized by the production and accumulation of extracellular matrix in various tissues, primarily the anterior segment of the globe, lens capsule, iris pigment epithelium, ciliary body, zonule of Zinn, and corneal endothelium [6, 17]. Clusters of pseudoexfoliation material (PEM) are associated with specific morphological changes in the globe. Patients with PES have an increased risk of zonule of Zinn rupture, posterior capsule rupture, and vitreous prolapse. In addition, during the postoperative period, they are at high risk of developing inflammation, posterior synechiae, posterior capsule opacity, anterior capsular phimosis, decentration, and intraocular lens (IOL) dislocation [21]. Zonular weakness and poorly dilated pupils are the main factors for intraoperative complications [19–21].

The primary aim of this study was to assess zonular weakness in patients with PES.

## MATERIALS AND METHODS

We examined 1,010 eyes in consecutive patients with age-related cataracts admitted to the 5th Department of Ophthalmology at City Hospital No. 2, Saint Petersburg, Russia, for cataract surgery between May 2016 and October 2017. Patients with congenital, traumatic, or uveal cataracts were not included in the study. We also excluded individuals with grade 2 and 3 lens subluxation (according

to the classification by N.P. Pashtae), as we avoid performing PE in these patients. If a patient was admitted for surgery on the second eye, they were enrolled in the study a second time, i. e., each operated eye was evaluated separately. All eyes were divided into two groups: the experimental group comprised 580 eyes with PES, whereas the control group comprised 430 eyes without PES. Thus, PES was detected in 57.4% of eyes with age-related cataracts. The diagnosis of PES was based on the detection of PEM in the anterior capsule of the lens, pupillary border of the iris, and anterior chamber angle. Patients in both groups were matched for gender and age (Table 1).

All patients underwent standard preoperative ophthalmologic examination that included visual acuity testing, perimetry, tonometry, biomicroscopy, gonioscopy, IOL calculation, and other examinations when appropriate.

PE was performed by one surgeon using the standard phaco chop technique (Alcon, USA) with implantation of various IOLs. During the postoperative period, all patients received standard anti-inflammatory therapy, including installations of dexamethasone in decreasing doses for four weeks and levofloxacin for two weeks.

Iridodonesis, phacodonesis, small and/or non-homogeneous anterior chamber, and a gap between the iris and lens were considered signs of grade 1 lens subluxation. Zonular weakness was assessed during surgery using the classification shown in Table 2. The following intraoperative characteristics and complications were considered markers of zonular weakness: lenticular substance located in the retrolental area (assessed subjectively by a surgeon according to the scale provided below), posterior capsule rupture (with or without vitreous body prolapse), and zonu-

Distribution by sex and age (*n* – number of eyes)

Table 1

Распределение групп по полу и возрасту (*n* — количество глаз)

Таблица 1

Parameter		Experimental group, <i>n</i> = 580	Control group, <i>n</i> = 430	Significance of the difference, <i>p</i>
Age		73.8 ± 3.8	72.9 ± 4.1	0.51
Gender	Male	116 (20%)	143 (33.3%)	0.21
	Female	464 (80%)	287 (66.6%)	

## Intraoperative classification of zonular weakness

Table 2

## Интраоперационная классификация слабости связочного аппарата хрусталика

Таблица 2

Grade	Characteristic
0	The capsular bag is stable.
1	The capsular bag is displaced at the first puncture of the anterior capsule by a capsulotome; the anterior capsule forms no folds.
2	The capsular bag is displaced at the capsulorhexis, which leads to its narrowing; the central rupture does not reach the edge of the pupil; the anterior capsule forms folds.
3	The capsular bag is displaced at the capsulorhexis, which leads to its narrowing; the central rupture reaches the edge of the pupil; the anterior capsule forms pronounced folds.
4	A surgeon has to use a second hand to stabilize the capsule bag.
5	Not possible to implant the IOL into the capsular bag without its additional fixation.
6	Not possible to preserve the capsular bag.
7	Not possible to perform phacoemulsification.

lar dialysis (with or without vitreous body prolapse). The presence of lenticular substance in the retrolental area was intraoperatively estimated by a surgeon by thorough examination of the anterior portion of the vitreous using the following scale: 1—small amount, 2 — moderate amount, and 3 — large fragments.

**RESULTS**

Preoperative grade 1 lens subluxation was detected in 9.50% of eyes with PES and 4.65% of eyes without PES ( $p = 0.004$ ) (Table 3). Zonular weakness of various grades (assessed intraoperatively, as described in the Material and Methods section) was observed in both groups; however, patients with PES had zonular weakness significantly more often. We observed only grade 1–3 zonular weakness probably because patients with grade 2 and 3 lens subluxation were excluded (Table 4).

- grade 1 zonular weakness: 114 eyes in the experimental group (19.7%) and 26 eyes in the control group (6%) ( $p = 0.0001$ );
- grade 2 zonular weakness: 34 eyes in the experimental group (5.9%) and 2 eyes in the control group (0.47%) ( $p = 0.001$ );

- grade 3 zonular weakness: 8 eyes in the experimental group (1.3%) and no eyes in the control group ( $p = 0.063$ ).

Complications are reported in Table 5. Lenticular substance in the retrolental area was observed in 16.9% of eyes with PES and only 6% of eyes without PES, which was a significant difference ( $p = 0.001$ ). A small amount of lenticular substance was found in 11.2% and 4.7% of PES and non-PES eyes, respectively, whereas a moderate amount was found in 5.7% and 1.4% of PES and non-PES eyes, respectively. None of the patients had posterior capsule rupture. Zonular dialysis was observed in 4 eyes in the PES group (2 eyes with vitreous body prolapse and 2 eyes without).

**DISCUSSION**

In the era of PE, PES presents significant obstacles for surgeons. Zonular weakness and poorly dilated pupils increase the risk of postoperative complications [11]. In addition to a thorough preoperative examination, patients with PES require especially high alertness during surgery. Particular attention should be paid to the assessment of zonular weakness.

1st degree of lens subluxation in groups (at preoperative assessment) ( $n$  — number of eyes)

Table 3

Подвывих хрусталика 1-й степени в группах (при дооперационном осмотре) ( $n$  — количество глаз)

Таблица 3

Parameter	PES group, $n = 580$	Non-PES group, $n = 430$	Significance, $p$
Lens subluxation (preoperative examination)	55 (9.5%)	20 (4.65%)	0.004

Note: PES — pseudoexfoliation syndrome

Table 4

Zonular laxity in groups (at intraoperative assessment) (*n* – number of eyes)

Таблица 4

Слабость связочного аппарата хрусталика, оцениваемая интраоперационно в группах (*n* — количество глаз)

Zonular weakness	PES group, <i>n</i> = 580	Non-PES group, <i>n</i> = 430	Significance, <i>p</i>
Grade 0	424 (73.1%)	402 (93.5%)	0.005
Grade 1	114 (19.7%)	26 (6%)	0.0001
Grade 2	34 (5.9%)	2 (0.47%)	0.0001
Grade 3	8 (1.3%)	–	(0.063)

Note: PES – pseudoexfoliation syndrome

Table 5

Intraoperative features and complications in groups (*n* – number of eyes)

Таблица 5

Интраоперационные особенности и осложнения в группах (*n* — количество глаз)

Parameter	PES group, <i>n</i> = 580			Non-PES group, <i>n</i> = 430			Significance, <i>p</i>
Lenticular substance located in the retrolental area	98 (16.9%)			26 (6.0%)			0.0001
	1	2	3	1	2	3	
	65 (11.2%)	33 (5.7%)	–	20 (4.7%)	6 (1.4%)	–	
Posterior capsule rupture	0			0			–
Zonular dialysis	4 (0.7 %)			–			0.26
	2 (0.35%) (with vitreous body prolapse)		2 (0.35%) (without vitreous body prolapse)				

Note: PES – pseudoexfoliation syndrome

Zonular weakness is associated with the accumulation of PEM in the zonule of Zinn and ciliary processes [8, 16, 18]. The prevalence of lens subluxation and/or phacodonesis in patients with PES varies between 8.4% and 10.6% [14, 16]. Zonular weakness can be evaluated during the slit-lamp examination in patients with phacodonesis, iridodonesis, small (less than 2.5 mm) and/or non-homogeneous anterior chamber, and a gap between the iris and lens [13, 14]. The dilated eye examination may mask phacodonesis due to the stretching effect of cycloplegic drops on the zonule of Zinn [20]. In our study, 9.5% of patients with PES and 4.65% of patients without PES were diagnosed with grade 1 lens subluxation at the initial examination ( $p = 0.004$ ). However, the intraoperative assessment of zonular weakness was more accurate because a surgeon evaluated the intraocular structures under high magnification and performed some manipulations, including anterior capsule puncture, with a capsulotome, continuous circular capsulorhexis, IOL implantation, etc. We developed an intraoperative classification of zonular weakness based on the evaluation of capsular bag stability (Table 2). The intraoperative assessment revealed a significantly higher prevalence of

zonular weakness compared with the preoperative examination: it was 300% higher in PES eyes and 150% higher in non-PES eyes. Therefore, the surgeon can be alerted to PES prior to surgery even in the absence of iridophacodonesis or other signs of lens subluxation.

The detection of lenticular substance in the retrolental area and zonular dialysis may also indicate zonular weakness. In this study, lenticular substance in the retrolental area was observed more frequently in patients with PES ( $p = 0.0001$ ). No residual lenticular substance was detected in the anterior portion of the vitreous body one day after surgery; however, it can be considered a risk factor for long-term postoperative inflammation in patients with PES. Zonular dialysis was observed in four patients with PES and was not detected in the control group; however, this difference was not statistically significant ( $p = 0.22$ ).

Patients with zonular weakness require particular attention during PE. It is important to avoid overfilling of the anterior chamber with solutions and viscoelastics, excessive rotation, and excessive pressure. Hydrodissection and hydrodelineation should be performed with particular caution. A capsular tension

ring (CTR) and/or capsular retractors can be used in patients with pronounced zonular weakness [1, 4, 10, 15]. However, we do not typically encourage CTR implantation for prophylactic support because it increases the weight of the whole complex IOL–capsule–CTR, causing greater injury to the zonule of Zinn during implantation. In our study, CTRs were implanted in four patients intraoperatively diagnosed with zonular dialysis.

The choice of phacoemulsification technique primarily depends on the surgeon's preference. We used the phaco chop technique, which requires minimal pressure on the zonule of Zinn and allows performing all manipulations in the center of the anterior chamber. We believe that gentle aspiration during PE is crucial in patients with PES (regardless of the PE technique) because it reduces the risk of zonular dialysis and posterior capsule rupture.

We observed no posterior capsule rupture in our cohort. It should be noted that patients with uveal, traumatic, or congenital cataracts were not included in this study. We did consider patients with traumatic cataracts and cataracts developed after posterior sub-total vitrectomy with a pronounced fibrous defect in the posterior capsule, but these patients did not meet the inclusion criteria. We did not enroll individuals diagnosed with grade 2 and 3 lens subluxation when we would rather perform a modified intracapsular lens extraction through a sclerocorneal tunnel with trans-scleral suture fixation of the IOL. Moreover, one month after completing patient recruitment, our surgeon performed PE, and posterior capsule rupture occurred during the removal of the last nuclear fragment (the surgeon was working in an unfamiliar operating room with another phaco machine). In our opinion, this emphasizes that careful aspiration is even more important when there are preoperative risk factors.

## CONCLUSIONS

1. Preoperative examination using a slit-lamp does not always reveal lens subluxation.
2. PES should alert the surgeon to zonular weakness.
3. Intraoperative assessment of zonular weakness significantly supplements the information obtained during the preoperative examination using a slit-lamp.
4. A better understating of the zonule of Zinn status allows correcting the parameters of the phaco machine and choosing an appropriate surgical technique.
5. Our findings suggest that PE can be effectively performed in patients with PES. However, it is a

difficult surgery that requires particularly careful manipulations with constant monitoring.

*The authors declare no conflict of interest related to this manuscript.*

## Author contributions:

V.V. Potemkin and E.V. Ageeva developed the research concept and study design, performed data collection and analysis, and drafted the manuscript.

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