A proposed classification of pseudoexfoliation syndrome

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Пропозиція класифікації псевдоексфоліативного синдрому

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Abstract

Purpose*: To develop a classification of pseudoexfoliation syndrome (PEX) for use in cataract surgery on the basis of its features.*

Material and Methods: *This study included 67 patients (67 eyes; age, 61 to 84 years) with PEX-associated cataract who underwent phacoemulsification with intraocular lens (IOL) implantation. Patients were divided into the following categories based on the features of surgical strategy: those that underwent standard phacovitrectomy without zonular protection; those that underwent phacoemulsification and no nucleus rotation during hydrodissection; those that required a capsular tension ring (CTR) implantation due to zonular weakness; and those that required suture IOL fixation.*

Results: *The patient distribution based on the features of PEX and severity of the effect of PEX on the features of phacoemulsification cataract surgery allowed to determine the relationship of the surgical strategy with the maximum pupil dilation, severity of zonular weakness, increased lens mobility, and capacity of an IOL to maintain its correct position independently. Determining the relationship allowed us to systematize these features and develop a surgical classification of PEX. The classification scheme defines four stages of the syndrome; stage II is subdivided into two categories, category A and category B.*

Conclusion: *The classification proposed was developed on the basis of the assessment of PEX in the above number of patients, and enabled systematizing the features of patients according to the features of the anterior segment of the eye. Moreover, the study is universal for the stages proposed. The classification can be used as a basis for further research on PEX.*

Keywords: *pseudoexfoliation syndrome, cataract, cataract associated with pseudoexfoliation syndrome, pseudoexfoliative glaucoma, phacoemulsification, intraocular lens position, intraocular lens fixation, pseudoexfoliation syndrome classification*

Резюме

Мета. *Розробити класифікацію псевдоексфоліативного синдрому для використання в хірургії катаракти на основі її особливостей.*

Матеріал та методи. *В дослідженні взяло участь 67 пацієнтів (67 очей) з псевдоексфоліативним синдромом та катарактою віком від 61 до 84 років, яким було проведено факоемульсифікацію кришталика з імплантацією ІОЛ. В залежності від особливостей хірургічної тактики лікування, пацієнтів розділено на наступні категорії: ті, кому факоемульсифікація катаракти проводилася стандартною методикою без додаткового захисту циннових зв'язок; ті, кому було необхідно проводити факоемульсифікацію без попередньої ротації ядра кришталика на етапі гідродисекції; ті, кому внаслідок слабкості циннових зв'язок була необхідна імплантація інтракапсульного*

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підтримуючого кільця; і ті, кому була необхідна шовна підтримка положення інтраокулярної лінзи.

Результати. *Розподіл пацієнтів за особливостями наявного псевдоексфоліативного синдрому і ступеню впливу останнього на характер проведення оперативного лікування методом факоемульсифікації дозволив вивести закономірності залежності тактики хірургічного лікування від максимального мідриазу, ступеню слабкості циннових зв'язок, рухомості кришталика і здатності самостійно триматися інтраокулярній лінзі в правильному положенні. Встановлення такої залежності дозволило систематизувати ці ознаки і розробити хірургічну класифікацію псевдоексфоліативного синдрому. Згідно з даною класифікацією, виділено чотири стадії псевдоексфоліативного синдрому, друга стадія поділена на дві категорії – категорію «А» і категорію «В».*

Висновки. *Запропонована класифікація, проведена на основі оцінки ПЕС у вищезазначеної кількості пацієнтів, дозволила чітко систематизувати особливості пацієнтів відповідно до особливостей переднього сегменту ока. Більше того, дослідження є універсальним для стадій, які ми запропонували.*

Дана класифікація може бути основою для подальших досліджень псевдоексфоліативного синдрому.

Ключові слова. *Псевдоексфоліативний синдром, катаракта, ускладнена псевдоексфоліативним синдромом, псевдоексфоліативна глаукома, факоемульсифікація, положення інтраокулярної лінзи, фіксація інтраокулярної лінзи, класифікація псевдоексфоліативного синдрому.*

Introduction

Pseudoexfoliation syndrome (PEX) is a disorder characterized by the accumulation of aberrant extracellular matrix material on the intraocular structures and other internal organs [1, 2]. The prevalence of PEX increases markedly with age. It is estimated that up to 20% of the over-60 population may be affected [3, 4]. Additionally, PEX is one of the most common causes of glaucoma worldwide, and is associated with 20-60% of open glaucoma cases in many regions of the world [1]. Moreover, PEX is known to be associated with cataract, which may require cataract surgery [5]. PEX is a risk factor in cataract surgery [6]. Surgery in patients with PEX may be additionally complicated due to pupil rigidity, poor mydriasis, zonular weakness, and, consequently, potential dislocation of the lens or intraocular lens (IOL) [7, 8, 9]. With regard to phacoemulsification in eyes with PEX, it is recommended to (1) avoid excessive pressure on the lens, (2) avoid making excessive efforts when moving or rotating the lens in the capsular bag, and (3) perform major phases of surgery at physiological intraocular pressure (IOP) and low vacuum parameters [10, 11, 12]. Such cases may also require options for capsular bag support (e.g., a capsular tension ring (CTR) implantation for more even distribution of tension on the zonular ligaments) [13]. Suture IOL fixation techniques are used in especially challenging cases of a partial or complete defect of the zonular ligaments, when it is impossible to achieve a correct IOL position postoperatively [14]. Means of sutureless or suture fixation are used to stabilize the IOL position during and after surgery [15]. Distributing patients according to the severity of PEX during surgery is important, because the above-mentioned features are present not in each case of surgery for cataract associated with PEX [16].

At present, there is no stage-by-stage differentiation of the syndrome; this differentiation, if present, could be helpful for surgical management of PEX.

Therefore, there is the need for a clinical classification of PEX that can be applied to determine the intraoperative strategy beforehand to prevent possible intraoperative complications.

The purpose of the study was to develop a classification of PEX for use in cataract surgery on the basis of its features.

Material and Methods

The study cohort included 67 patients (67 eyes; age, 61 to 84 years) with PEX-associated cataract who underwent surgery at the Visiobud Clinic from 03.12.2024 to 17.04.2025. Patients with high ametropia or ocular comorbidities were excluded. All patients underwent cataract surgery by phacoemulsification with IOL implantation. All surgeries were performed by one fully-qualified ophthalmic surgeon. Patients were divided into the following groups based on the features of surgical treatment: group 1, patients exhibiting no preoperative or intraoperative zonular weakness, and thus requiring no zonular protection (during hydrodissection of the nucleus, rotational mobility of the lens was easily achieved without risk for the zonular ligaments); group 2, patients exhibiting pronounced zonular weakness in the form of increased lens mobility (these patients required phacoemulsification with additional zonular protection, including hydrodissection of the nucleus without rotation and performing phacoemulsification phases at physiological IOP and low vacuum parameters; a CTR was employed in some of these patients due to significant intraoperative zonular weakness); group 3 (patients with

Table 1. Classification of pseudoexfoliation syndrome (PEX) in cataract surgery

Stage of PEX	Number of patients	Biomicroscopic finding	Pupil width	Phacodonesis or iridodonesis	Lens or IOL dislocation	Surgical intervention of choice
PEX 1	22	PEM along the papillary margin and on the anterior surface of the lens in a dilated eye	> 8 mm	No	No	Standard phacoemulsification with IOL implantation
PEX 2A	20	PEM along the papillary margin, on the anterior surface of the lens in a dilated eye, in the angle of the anterior chamber, and on the iris and corneal endothelium	5-8 mm	Mild and do not require fixation device implantation	No	Phacoemulsification at physiological IOP, no nucleus rotation, low vacuum parameters, with IOL implantation with no fixation device
PEX 2B	13	PEM along the papillary margin, on the anterior surface of the lens in a dilated eye, in the angle of the anterior chamber, and on the iris and corneal endothelium	5-8 mm	Clinically and intraoperatively pronounced, require implantation of a fixation device (capsular tension ring, etc.)	No	Phacoemulsification at physiological IOP, no nucleus rotation, low vacuum parameters, with IOL implantation with a fixation device (a capsular tension ring)
PRX 3	11	PEM along the papillary margin, on the anterior surface of the lens in a dilated eye, in the angle of the anterior chamber, and on the iris and corneal endothelium	< 5 mm	Clinically and intraoperatively pronounced, require implantation of a fixation device (capsular tension ring, etc.)	No	Phacoemulsification at physiological IOP, no nucleus rotation, low vacuum parameters, with IOL implantation with a fixation device (a capsular tension ring)
PEX 4	1	PEM along the papillary margin, on the anterior surface of the lens in a dilated eye, in the angle of the anterior chamber, and on the iris and corneal endothelium	< 5 mm	Clinically and intraoperatively pronounced	Partial or complete dislocation	Phacoemulsification at physiological IOP, no nucleus rotation, low vacuum parameters, with an IOL sutured to the sclera or iris

Note: IOP, intraocular pressure; PEM, pseudoexfoliative material; PEX, pseudoexfoliation syndrome. We report holding a Copyright Patent for this classification (Copyright Patent No. 136593 issued on May 26, 2025).

marked signs of phacodenesis and iridodonesis and preoperative lens dislocation; these patients required adequate capsular bag support in the form of capsular hooks at all stages of surgery, and additional suture IOL fixation to achieve a correct IOL position postoperatively). Pupil diameter was measured intraoperatively in the presence of epibulbar treatment with tropicamide 1% or atropine 1% and intracameral treatment with mesatone 1% for maximal mydriasis. No intraoperative or postoperative complications occurred.

The study followed ethical standards as outlined in the Declaration of Helsinki and the European Convention on Human Rights and Biomedicine, and relevant laws of Ukraine. Informed consent was obtained from all subjects.

Results

Group 1 included 22 patients in whom the course of surgical intervention was not different from that in patients without PEX: the lens was stable; there was no intraoperative evidence of zonular weakness; during hydrodissection of the nucleus, rotational mobility of the lens was easily achieved; intraoperative IOP and vacuum were standard and required no correction; the implanted IOL was stable in the capsular bag and correctly positioned in the eye. The use of mydriatics allowed pupil dilation to a diameter exceeding 8 mm. These patients were assigned to group I of our classification of PEX.

Group 2 included 33 patients with preoperative signs of increased mobility of the nucleus in the form of iridodonesis during ocular movements and intraoperative mobility of the lens due to zonular weakness when creating an anterior capsulorhexis. No nucleus rotation, but performing phacoemulsification at physiological IOP and low vacuum parameters for preventing damage to weakened zonules (Centurion Vision System, Alcon, Fort Worth, TX) was required (with fragmentation and aspiration vacuum settings of 90-120 mmHg and 180-250 mmH, respectively) in these patients. Some of these patients also required a CTR placement to stabilize the IOL in the postoperative period. In all these 33 patients, the pupil could be dilated to a diameter of < 8 mm. In 11 patients, the pupil could be dilated to a diameter of < 5 mm; they required a CTR implantation. Therefore, the patients exhibiting pronounced zonular weakness and maximum pupil dilation of < 5 mm were assigned to group III of our classification of PEX. All such patients require a CTR implantation. The patients exhibiting pronounced zonular weakness (that required corresponding changes in phaco settings) and maximum pupil dilation of 5 to 8 mm were assigned to group II. The patients not requiring a CTR implantation were assigned to group IIA, and the patients requiring a CTR implantation, to group IIB.

Patients with preoperative or intraoperative signs of PEX or lens or IOL dislocation required the IOL to be sutured to the sclera or iris, and were assigned to group IV irrespective of the maximal pupil dilation.

The postoperative period was unremarkable in all patients.

In 8 eyes (12%), topical hypotensive medications were used due to early postoperative ocular hypertension. The IOL was well centered in all patients.

It was proposed to systematize patients with PEX into the classification system based on (1) the scores of preoperative anterior segment biomicroscopy, (2) maximal intraoperative pupil dilation, and (3) intervention features.

Discussion

This surgical classification of PEX has a large practical value since it allows determining preoperatively the amount of surgical intervention in the anterior segment based on the maximal pupil dilation and the presence or absence of signs of zonular weakness and phacodenesis. This is helpful in determining potential risks, the need for the use of additional IOL fixation, and the eye surgeon qualification level required to perform eye surgery adequately.

Moreover, this enables providing a rationale for the development of PEX [17]. The degree of PEX severity is very important in the context of the prevention of pseudoexfoliative glaucoma (PEG), because cataract surgery in patients with PEX reduces the risk of PEG [17, 18].

The fact that not all patients with PEX will develop PEG prompts a search for potential factors of PEG in these patients; consequently, the possibility for classifying PEX allows for more fundamental research on PEG.

PEX is typical not only in phakic patients, but also in pseudophakic individuals. Undiagnosis of PEX is common in pseudophakic patients [19].

The above classification of PEX can be used both in phakic and pseudophakic individuals.

Conclusions

Since the presence of visual signs of PEX does not determine the strategy of cataract surgery, there is a need for a classification of PEX not on the basis of the presence or amount of pseudoexfoliative material, but on the basis of the signs that influence the strategy of surgery. These signs include the maximum pupil dilation; evidence of phacodenesis or iridodonesis; increased mobility of the lens during phacoemulsification; the potential for using various cataract surgery techniques without damage to ligaments or dislocation of the lens or IOL; and, correspondingly, the advisability of suture fixation in cases with dislocation of the lens or IOL.

This classification enables predicting the course of surgery and the risks of intraoperative complications and PEG.

The classification proposed was developed on the basis of the assessment of PEX in the above number of patients, and enabled systematizing the features of patients according to the features of the anterior segment of the eye. Moreover, the study is universal for the stages proposed. The classification can be used as a basis for further research on PEX, particularly in the context of the development of PEG.

Author Contributions

Melnyk V.O. – concept development, design, analysis and interpretation of data, data collection and conduct of the study, preparation and review of the manuscript; Vasilyeva L.S. – data collection and conduct of the study, preparation and review of the manuscript. All authors read and approved the final version of the manuscript.

Sources of support

None.

Ethical standards

This study was conducted with the participation of humans. All patients gave informed consent to participate in the study. The study was conducted in accordance with the Declaration of Helsinki. This study did not include animal experiments.

Conflicts of interest

The authors declare that they have no conflict of interest that could influence their opinion on the subject or materials described and discussed in this manuscript.

Disclaimer

The views expressed in the submitted article are their own and do not represent the official position of the institution or sponsor.

Data Availability Statement

All data obtained or analyzed during this study are included in this published article.

Abbreviations

PES – pseudoexfoliative syndrome; PEG – pseudoexfoliative glaucoma; IOL – intraocular lens..

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