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Evaluation strength of the supporting apparatus of the lens at combination of age-related cataract with involutional changes in connective tissue

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AIM: The clinical evaluation of zonules condition in patients with age-related cataracts without weak zonular support signs against the background of connective tissue somatic involutional changes.

MATERIALS AND METHODS: The main group consisted of 70 patients (70 eyes) with connective tissue involutional somatic pathology without concomitant eye pathology, eye injuries, and decompensated systemic diseases; the control group included 60 people (60 eyes) with age-related cataracts without connective tissue involutional pathology. Using ocular echography (Aviso S, Quantel Medical, France) with high resolution (50 MHz) sensor, we estimated the “ciliary processes to lens equator” distance symmetry in 2 main meridians (of 6 and 12 hours). Its equal value in 2 opposite meridians or difference less than 0.3 mm between them was considered as the sign of symmetry; the difference of 0.3 mm and more was a sign of asymmetry.

RESULTS: The presence of “ciliary processes to lens equator” distance asymmetry between the meridians was revealed in 28 eyes in the main group (40%); in 14 of the eyes with asymmetry ranging from 0.4 and more, a 1st degree lens subluxation was revealed intraoperatively.

CONCLUSIONS: The presence of “ciliary processes to lens equator” distance asymmetry indicates subclinical involutional changes in the lens’ ligament apparatus, which has a prognostic value for choosing a model of an intraocular lens to be implanted.

Keywords: age-related cataract; zonule of Zinn; involutional changes in connective tissue; ultrasound biomicroscopy.

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Оценка прочности поддерживающего аппарата хрусталика при сочетании возрастной катаракты с инволюционными изменениями соединительной ткани

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Цель — клиническая оценка состояния цинновой связки у пациентов с возрастной катарактой без признаков слабости зонулярной поддержки на фоне соматических инволюционных изменений соединительной ткани.

Материалы и методы. Основная группа состояла из 70 пациентов (70 глаз) с инволюционной соматической патологией соединительной ткани без сопутствующей глазной патологии, травм глаза, системной декомпенсированной патологии; группа контроля — из 60 человек (60 глаз) с возрастной катарактой без инволюционной патологии соединительной ткани. С помощью офтальмологического эхографа (Aviso S, Quantel Medical, Франция) с датчиком высокого (50 МГц) разрешения оценивалась симметричность дистанции «отростки цилиарного тела – экватор хрусталика» в двух основных меридианах на 6 и 12 ч. Признаком их симметрии в двух противоположных меридианах считалось отсутствие разницы либо её значения менее 0,3 мм; признаком асимметрии — наличие разницы в 0,3 мм и более.

Результаты. Наличие асимметрии дистанции «отростки цилиарного тела – экватор хрусталика» между меридианами выявлено в 28 глазах основной группы (40 %), из них в 14 глазах с наличием асимметрии от 0,4 и выше интраоперационно нами был выявлен подвывих хрусталика 1-й степени.

Заключение. Наличие асимметрии дистанции «отростки цилиарного тела – экватор хрусталика» свидетельствует о субклинических процессах инволюционных изменений связочного аппарата хрусталика, что имеет прогностическое значение для выбора имплантируемой модели интраокулярной линзы.

Ключевые слова: возрастная катаракта; циннова связка; инволюционные изменения соединительной ткани; ультразвуковая биомикроскопия.

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INTRODUCTION

Spontaneous dislocation of the “intraocular lens (IOL)–capsular bag” complex in the eyes after phacoemulsification (PE) of age-related cataract is becoming an urgent problem. It is caused by progressive weakening of the zonular support of the lens [1–15].

In recent years, a number of factors were elucidated, which weaken the strength of the zonules and led to an increased risk of spontaneous dislocation of the IOL–capsular bag complex. These factors include pseudoexfoliation syndrome, glaucoma, lengthened anteroposterior axis of the eye, and retinitis pigmentosa [3, 7, 16–18].

However, these conditions probably are far from covering all possible causes of zonular weakness. Therefore, identification of new predictors of the risk of weakening lens zonular support appears relevant [8, 9].

Fibrillin is known to be the biochemical basis of microfibrils that compose the elastic fibers of the zonular apparatus of the lens. It is a non-collagenous glycoprotein rich in cysteine and linked to oligosaccharides through O- and N-bonds. Fibrillin also serves as the structural basis of the ligamentous articular apparatus and the vascular wall of veins and arteries [6, 19–21]. Systemic progressive dystrophic changes occur with age. Accordingly, the zonules can also be exposed to involutionary degradation [22–24].

Somatic involutional lesions of the connective tissue based on fibrillin that occur and progress in old age, are most often represented by degenerative deformities of the spine, which result from the weakening of its ligamentous apparatus. In addition, varicose veins of the lower extremities, which often contribute to the development of chronic venous insufficiency, represent a common involutional systemic condition of the connective tissue. Thus, the prevalence of degenerative scoliosis in old age varies from 6% to 68% [21, 25, 26], and that of varicose veins of the lower extremities is at least 25% [19, 27].

The main clinical manifestation of degenerative involutional changes in the spinal ligamentous apparatus is sagittal vertebral–pelvic imbalance caused by the weakening of the ligamentous apparatus of the intervertebral discs and the dysfunction of the muscles of the lumbar–pelvic region. This results in a spinal curvature in the frontal plane, chest deformity, costal humpback, and deviation of the trunk toward the main arch of the spinal curvature, leading in severe cases to heart and lung dysfunction [21, 26].

Varicose veins of the lower extremities, which result from the loss of strength of the elastic fibers of the vessels, lead to thinning of the venous wall, increase in the lumen of the veins, tortuosity of the venous trunks and their deformity, especially the deep veins of the lower extremities, as well as the formation of venous nodes. This eventually results in impaired blood outflow via

the affected vein with venous congestion and development of chronic venous insufficiency. Furthermore, this leads to a decrease in the trophism of the tissues of the lower extremities up to the formation of trophic ulcers [19, 27].

As crucial aspect a fact is considered that the intensity of the involutional processes of connective tissues largely varies among individuals [24, 28, 29].

Since the weakening of the spinal ligamentous apparatus and that of the vascular wall's structure are based on similar degenerative processes of connective tissues, it appeared logical to analyze the state of zonular support in patients with age-related cataracts who have concomitant somatic involutional changes in connective tissues. However, we did not find such information in the literature, although it is of practical interest since this systemic condition of the connective tissue is widespread in the older population. Data obtained could help in predicting the formation and progression of zonular support weakness with the development of spontaneous dislocation of the IOL–capsular bag complex.

At the preoperative stage, signs of zonular support weakness are often not detected, so it is considered to be intact. Therefore, we decided to assess in more detail the zonular support status in patients without obvious preoperative signs of its weakness.

This study aimed to provide a clinical assessment of the zonule status in patients with age-related cataracts without signs of zonular support weakness in the presence of somatic involutional changes in connective tissues.

MATERIALS AND METHODS

The criteria for inclusion of patients in the main group were as follows:

- Combination of age-related cataracts with degenerative kyphoscoliosis or varicose veins of the lower extremities.
- Absence of obvious clinical manifestations of zonular support weakness (i.e., iridophacodonesis, uneven depth of the anterior chamber revealed by anterior segment biomicroscopy).
- Absence of eye conditions associated with the weakness of the lens zonular support (glaucoma, pseudoexfoliation syndrome, high-degree myopia, and retinitis pigmentosa) and history of head and eye injuries.
- Absence of lens intumescence.
- No history of previous surgeries (endovitreals and anti-glaucoma) and no pseudophakia in both eyes.
- Absence of any other concomitant somatic decompensated condition in addition to connective tissue pathological condition.

Based on the above criteria, the main group consisted of 70 patients (70 eyes) with both age-related cataract

and involutonal connective tissue pathological condition. Of these patients, 33 were men and 37 were women aged 57–82 years.

All patients had visited the Khabarovsk branch of the National Medical Research Center Academician S.N. Fedorov Interbranch Scientific and Technical Complex “Eye Microsurgery” for surgical treatment of age-related cataracts. The preoperative examination revealed the absence of obvious signs of lens subluxation in any case. Two subgroups of the main group were formed according to the variant of clinical manifestations of the concomitant systemic connective tissue condition.

Subgroup 1 included 32 patients with grade 3 and 4 degenerative kyphoscoliotic deformity (grade 3 showed curvature of the chest with the formation of a hump in the area of the ribs; grade 4 manifested itself with severe curvature of the spinal column, pelvis, and chest with development of the anterior and posterior humps, according to the clinical classification of kyphoscoliosis by Chaklin [25, 26]).

Subgroup 2 of the main group included 38 patients with varicose veins of the lower extremities, complicated by grade 2 and 3 chronic venous insufficiency (since earlier stages cannot be verified without ultrasonic dopplerography). This condition was revealed by presence of dilation of the superficial veins from small vessels to large ducts and main trunks, edema of the distal parts of the lower extremities, nocturnal seizures, paresthesia, and pain in the extremities according to CEAP classification adopted in 1994 [19, 27].

In all cases, the diagnoses of kyphoscoliosis and varicose veins of the lower extremities were established by physicians in accordance with the clinical classifications. As regards the stages of age-related cataracts, 23 and 47 eyes were in the initial and immature stages, respectively. The optical density of the nucleus of the lens was of 2–3 grades according to the Buratto classification of 1999. The anteroposterior axis length varied from 21.36 to 25.08 mm (average, 23.2 ± 0.05 mm).

Both subgroups appeared comparable in terms of cataract stages and of the lens nucleus optical density. The control group included 60 patients (60 eyes), aged 52–85 years old, with initial age-related cataract without involutonal connective tissue pathological conditions.

Assessment included the parameters of maximum pupil diameter under drug-induced mydriasis conditions, anterior chamber depth, and symmetry of the “ciliary processes–lens equator” distance. Signs of lens zonular support weakness were revealed intraoperatively.

Pupil diameter was assessed by biomicroscopy 20 min after three instillations of 10% Midrimax solution [2]. Occurrence of pupil rigidity was monitored, as this indirectly indicates involutonal dystrophic changes in the zonules [2, 5, 7].

The anterior chamber depth was measured by optical biometrics in the center of the optical zone in both eyes (IOL Master 700, Carl Zeiss, Germany). The distance from the corneal endothelium to the anterior lens capsule was determined, and some eyes were asymmetric relative to the fellow eye (sign of latent grade I lens subluxation) [2]. Asymmetry of more than 1 mm may indicate grade 1 lens subluxation.

The ciliary processes–lens equator distance was assessed using ultrasound biomicroscopy, and its symmetry was examined in two main meridians (at 6 and 12 o'clock positions). We chose these meridians because when the zonular support is weakened, the lens is displaced primarily from the top to the bottom because of its gravity. The study was performed using an ophthalmic echograph (Aviso S, Quantel Medical, France), with a high-resolution 50-MHz transducer. According to Professor E.V. Egorov, asymmetry of these indices >0.3 mm was regarded as an objective sign of zonular weakness [12, 30]. Earlier, we also confirmed the predictive value of the index as 0.3 and higher [8, 9].

The final stage of assessing the integrity of the zonules was performed intraoperatively. According to Belonozhenko, the criteria for latent grade 1 lens subluxation include deepening and unevenness of the anterior chamber depth during the injection of viscoelastic substance, folding of the lens anterior capsule when performing anterior capsulorhexis, motility of the lens at the PE stage, and appearance of tiny lens masses in form of small dispersed particles on the anterior hyaloid membrane of the vitreous [31].

Differences in the analyzed indices of the main and control groups, as well as between the subgroups of the main group, were investigated.

Statistical data processing was performed using IBM SPSS Statistics 20 (IBM Corp., Armonk, NY, USA). Qualitative characteristics were compared using Fisher's exact two-tailed test. Multiple group comparisons were performed with the Holm–Bonferroni adjustment. The critical level of significance was 0.01.

RESULTS

Data obtained are presented in Table. In the control group, the pupil diameter at drug-induced mydriasis varied from 5.0 to 6.0 mm. Moderate pupil rigidity with 4.0 mm diameter was detected in 1 (2%) eye. The depth of the anterior chamber varied from 2.5 to 3.3 mm (average, 3.0 ± 0.2 mm). In all patients, the studied and fellow eyes were comparable, and the degree of asymmetry did not exceed the measurement error of 0.2 mm. In 57 eyes (95%), there was no asymmetry in the ciliary processes–lens equator distance, and in 3 (5%) eyes, it was 0.3 mm. Intraoperatively, folds of the anterior capsule appeared in these three eyes during the anterior capsulorhexis.

However, at the stage of nucleus emulsification, its motility was not detected because in these cases only initial manifestations of zonular weakness, without grade 1 lens subluxation, were observed.

In subgroup 1 of the main group, the maximum pupil diameter at drug-induced mydriasis varied from 4.0 to 5.0 mm. Moderate rigidity with 4.0 mm diameter was detected in 5 (16%) eyes. The average anterior chamber depth was 3.0 ± 0.5 mm (range, 2.4–3.61 mm); in 27 (84%) patients, no difference in indices was found. Asymmetry of the anterior chamber depth was found in 5 (16%) patients when compared with the fellow eye, and the difference ranged from 0.2 mm to 0.5 mm, but no iridophacodonesis was noted. In 11 (34%) eyes, there was an asymmetry in the ciliary processes–lens equator distance in two meridians. The distance was 0.3–0.4 mm in five eyes, 0.5–0.6 mm in four eyes, and 0.8 mm in two eyes. Intraoperatively, when performing anterior capsulorhexis in 5 of 11 eyes with asymmetric distance, there was an uneven depth of the anterior chamber, folding of the anterior capsule of the lens (Fig. 1), and motility of the lens during emulsification of the nucleus (Fig. 2). This objectively confirmed the presence of grade 1 lens subluxation (16%). Consequently, these aspects caused technical difficulties in performing anterior capsulorhexis and emulsification of the lens nucleus.

In subgroup 2 of the main group, the maximum pupil diameter at drug-induced mydriasis ranged from 4.0 to 6.0 mm. A pupil rigidity with up to 4.0 mm diameter was observed in 6 (16%) eyes. The anterior chamber depth varied from 2.8 to 3.7 mm (average, 3.1 ± 0.3 mm). In 4 (11%) patients, the affected eye was smaller than the fellow eye, and the asymmetry varied from 0.3 to 0.5 mm. In 17 (45%) eyes, there was an asymmetry in the ciliary processes–lens equator distance between the meridians investigated: the asymmetric distance was 0.3–0.4 mm in nine eyes, 0.5–0.6 mm in seven eyes, and 0.7 mm in one eye. Intraoperatively, in 8 (21%) eyes, folding of the anterior lens capsule was detected during the anterior capsulorhexis, and lens motility was revealed during emulsification of the nucleus.

The incidence of pupil rigidity was higher in the study group than in the control group (16 versus 2% of cases, respectively, $p = 0.006$). The incidence of asymmetry in the depth of the anterior chamber in fellow eyes was 16% and 11% in both subgroups of the main group, and this asymmetry was completely absent in the control group.

Certain differences were detected between the incidence rates of asymmetry of the ciliary processes–lens equator distance in both subgroups of the main group. Thus, asymmetry was more common in subgroup 2 with

Table. Comparative analysis of frequency of pupil rigidity, asymmetry of anterior chamber depth, the distance “ciliary processes – lens equator”, the frequency of intraoperative cases of lens subluxation of 1st degree

Таблица. Сравнительный анализ частоты ригидности зрачка, асимметрии глубины передней камеры, дистанции «отростки цилиарного тела – экватор хрусталика», частоты интраоперационных случаев подвывиха хрусталика 1-й степени

Group	Pupil rigidity, <i>n</i> (%)	Asymmetry of the anterior chamber depth, <i>n</i> (%)	Asymmetry in the ciliary processes–lens equator distance in two meridians, <i>n</i> (%)	Grade 1 lens subluxation, <i>n</i> (%)
Main Group (<i>n</i> = 70)	11 (6)	9 (13)	28 (40)	14 (20)
Control Group (<i>n</i> = 60)	1 (2)*	–	3 (5)*	–

* Statistically significant difference from the main group, $p < 0.01$.

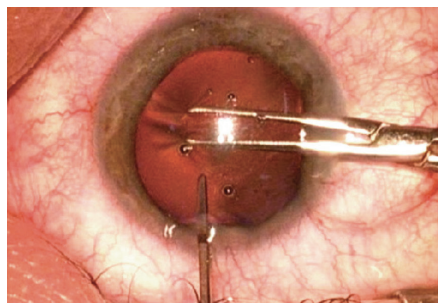


Fig. 1. Anterior lens capsule folds during performing anterior capsulorhexis

Рис. 1. Складчатость передней капсулы хрусталика при выполнении переднего капсуло-рексиса

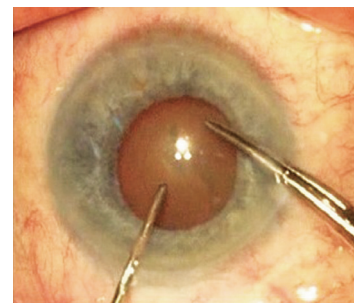
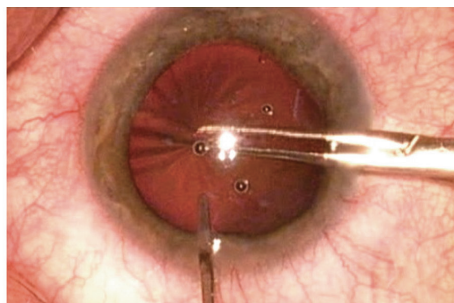


Fig. 2. Lens mobility during emulsifying the nucleus

Рис. 2. Подвижность хрусталика при эмульсификации ядра

17 eyes (45%) than in 11 eyes in subgroup 1 (34%). However, owing to the insufficient number of eyes in both groups, no significant differences were found ($p = 0.46$). The asymmetry of the ciliary processes–lens equator distance revealed in 28 eyes of the main group (40%) was significantly different from that of the control group (3 eyes, 5%, $p < 0.01$).

In the main group, the asymmetry of the anterior chamber depth was observed in 5 (16%) eyes of subgroup 1 and in 4 (11%) eyes of subgroup 2. It was not detected in the control group.

Intraoperative signs of grade 1 lens subluxation were noted in six eyes of subgroup 1 and in eight eyes of subgroup 2 in the main group (19% and 21%, respectively), showing no significant difference. In the control group, no cases of grade 1 lens subluxation were recorded.

DISCUSSION

Preventing subluxation of the IOL–capsular bag complex is becoming an urgent problem. It becomes evident that the standard preoperative eye examination is ineffective in revealing the latent weakness of the zonules [1, 8, 9]. Thus, it is necessary to identify new predictors that would enable in the preoperative period to identify a group of patients at risk for zonular support weakness before PE of age-related cataract.

This study revealed that patients with age-related cataracts and systemic somatic involutonal connective tissue pathologic conditions have significant characteristics showing the state of ciliary support. These patients demonstrated a high frequency of latent zonular support weakness, which is detected mainly only intraoperatively, in comparison with patients with age-related cataracts without somatic connective tissue pathologic conditions. The state of ciliary support is detected during preoperative diagnostics in terms of the asymmetry of the ciliary processes–lens equator distance in two meridians, and intraoperatively by the presence of signs of grade 1 lens subluxation, but no such changes were found in the control group.

Consequently, patients with age-related cataract should be monitored for the presence of background

systemic involutonal connective tissue pathologic conditions. This may be a risk factor for zonular support weakness and spontaneous dislocation of the IOL–capsule bag complex at various times in the postoperative period.

CONCLUSIONS

A significant difference was found between patients with age-related cataracts with and without systemic somatic involutonal connective tissue pathology in terms of the incidence of pupil rigidity (16% versus 2%, $p = 0.006$), asymmetry of the anterior chamber depth in fellow eyes (13% versus 0%), and asymmetry of the ciliary processes–lens equator distances in two opposite meridians (40 versus 5%, $p < 0.01$).

The incidence rates of intraoperative detection of grade 1 lens subluxation in subgroups 1 and 2 of the main group were 19% and 21% of the eyes, respectively, but this was not found in the control group.

The revealed characteristics of the initial state of zonular support of the lens in patients with age-related cataracts and systemic involutonal connective tissue pathologic conditions are of great prognostic value for the timely prediction of the risk of spontaneous dislocation of the IOL–capsular bag complex. These features should be considered when planning PE for assessing the possibility of a stable long-term position of the IOL implanted in the capsular bag.

ADDITIONAL INFORMATION

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Author contributions. E.L. Sorokin created the concept and design of the study, approved the manuscript for publication; Ya.V. Belonozhenko analyzed the data and interpreted the results; S.V. Krivko obtained the data (direct execution of research) and analyzed the data; O.V. Danilov obtained the data (direct execution of research) and analyzed the data.

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