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Pseudophakic/ aphakic corneal edema – morphometric predisposing factors analysis based on the fellow eye examination

Rzekomosoczewkowy/ bezsoczewkowy obrzęk rogówki – analiza morfometrycznych czynników predysponujących na podstawie badania oka towarzyszącego

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Streszczenie: Cel: znalezienie morfometrycznych czynników predysponujących do rozwoju dekompensacji rogówki po zabiegu usunięcia zaćmy.
Materiał i metody: grupę badaną stanowiło 50 pacjentów po przeprowadzonej keratoplastyce z powodu pseudosoczewkowego/ bezsoczewkowego obrzęku rogówki. Grupę kontrolną utworzono z 50 osób po przeprowadzonym zabiegu usunięcia zaćmy bez cech dekompensacji rogówki. Analizowano również specjalnie wydzielone podgrupy. Dane morfometryczne przedniej komory oka towarzyszącego uzyskano za pomocą aparatu Visante OCTTM.
Wyniki: parametry głębokości przedniej komory oraz szerokości kąta przedniej komory były znacząco mniejsze w grupie badanej ($p<0.00001$, test U). Po wykluczeniu przedoperacyjnych czynników ryzyka: dystrofii Fuchsa, przebytego ostrego ataku jaskry, także uzyskano znaczące różnice w porównaniach z $p<0.01$. W podgrupach dystrofii Fuchsa oraz powikłań śródoperacyjnych te dwa parametry przedniej komory były również mniejsze z $p<0.001$. Szerokość przedniej komory była mniejsza w grupie badanej z $p = 0.001$. Centralna grubość rogówki była większa w grupie badanej z $p = 0.013$. Po wykluczeniu pacjentów z dystrofią Fuchsa nie było różnicy w porównaniu tego parametru ($p = 0.34$). Różnica w długości gałki ocznej nie była istotna statystycznie ($p = 0.18$). U 31 pacjentów z grupy badanej rozpoznano względne przednie małoocze, w grupie kontrolnej stan ten wystąpił u 17 pacjentów.
Wnioski: małe wymiary przedniej komory oraz większa grubość centralnej rogówki są czynnikami wpływającymi na ryzyko rozwoju rzekomosoczewkowego/ bezsoczewkowego obrzęku rogówki.

Słowa kluczowe: rzekomosoczewkowy/ bezsoczewkowy obrzęk rogówki, morfometria przedniej komory, względne przednie małoocze.

Summary: Purpose: To find morphometric factors predisposing to the development of corneal decompensation following cataract surgery.
Material and methods: Study group consisted of 50 patients after keratoplasty performed as pseudophakic/ aphakic corneal edema (PCE/ACE) treatment. Control group formed 50 patients after cataract removal without signs of corneal decompensation. Specific subgroups were analyzed too. The morphometric data of the fellow eye anterior chamber were obtained with Visante OCTTM.
Results: Anterior chamber depth and anterior chamber angle width were significantly smaller in study group ($p<0.00001$, U-test). With excluded preoperative risk factors: Fuchs dystrophy, acute angle closure glaucoma attack history the significant differences were also observed ($p<0.01$). In Fuchs' dystrophy and intraoperative complication subgroups comparison these two anterior chamber parameters were smaller too ($p<0.001$). Anterior chamber width was also smaller in study group with $p = 0.001$. Central corneal thickness was higher in study group with $p = 0.013$. After exclusion of patients with Fuchs' dystrophy there was no difference in comparison ($p = 0.34$). The difference in total axial length comparison was insignificant ($p = 0.18$). Relative anterior microphthalmos was diagnosed in 31 patients of study group (62%) and in 17 of control (34%).
Conclusions: Small anterior chamber dimensions and higher central corneal thickness due to Fuchs' dystrophy are factors influencing the risk of PCE/ACE development.

Key words: pseudophakic/ aphakic corneal edema, anterior chamber morphometry, relative anterior microphthalmos.

Introduction

Pseudophakic/aphakic corneal edema (PCE/ACE) is an irreversible corneal decompensation, developed as a result of cataract surgery. In the age of novel intraocular surgery the frequency of this severe postoperative complication reduces. Estimated frequency average 3–6 cases per 1000 operations

however it still represents the major indication (7.6–31.5% of causes) to perform keratoplasty, which is the only causal PCE/ACE treating method.

The aim of this study is to find anatomical predisposing factors of PCE/ACE development based on the comparative analysis of the fellow eye morphometry in patients after keratoplasty due to PCE/ACE and in patients without signs of corneal decompensation after cataract surgery.

Material and methods

In the Department of Ophthalmology there were 915 keratoplasty procedures performed between 2000-2006. Among these 231 (25%) procedures were done to treat pseudophakic/aphakic corneal edema (191 procedures were penetrating keratoplasty and 40 procedures were deep lamellar endothelial keratoplasty). Earlier cataract operations were performed in different departments between years 1986–2004.

Analyzed groups were created with taking into assumption similarity of initial status of both eyes of each particular patient before cataract surgery. Therefore, exclusion criteria were: performed cataract surgery or keratoplasty in the fellow eye, chemical or mechanical eye injury, anterior segment inflammation history, anizometropy in anamnesis. Based on consideration of qualitative attributes of study group patients: Fuchs' dystrophy (FD), angle-closure glaucoma attack history (AACG) and intraoperative complications (COMPL – capsular damage/vitreous loss), specific subgroups were created and compared.

Finally 50 patients (18 men and 32 women) after keratoplasty performed to treat PCE/ACE were examined as a study group. A control group was created by 50 patients (18 men and 32 women), after cataract operation without signs of corneal decompensation from among people admitted to department for second eye cataract operation.

In both groups morphometric data of anterior segment of the fellow eye were obtained by anterior segment optical coherence tomography Visante OCT™. Anterior segment single scans with possibility of achieving data of anterior chamber depth (ACD), anterior chamber width (ACW), anterior chamber angle width (ACAW) and central cornea thickness (CCT) were analyzed. Total axial length (TL) was measured by contact A scan ultrasonography (Quantel Medical). Results are the mean of ten measures. All data in both groups were taken by the fellow eye examination.

Selected and grouped quantitative (age, morphometry) and qualitative (FD, AACG, COMPL) data were compared and statistically analyzed. Subgroups were formed by the exclusion of patients with endothelial dysfunction suspicion (subgroup without FD, subgroup without AACG, subgroup without DF and AACG), and by predisposing states isolation (FD subgroup, COMPL subgroup). In both groups relative anterior microphthlmos (RAM) patients were identified according to Naumann (1) criteria: axial length >20.0 mm and white-to-white corneal diameter <11.0 mm corresponding to ACW measures <11.5 mm on Visante OCT™ scans.

Results were compared using the Student t test (t test) for groups with normal data distribution otherwise the Mann-Whitney U test (U test) was used with statistically significant p values <0.05 (Statistica StatSoft Inc.).

Additionally data were registered and analyzed on diagrams in quantitative attributes coordinates ACD *vs.* ACAW with consideration of qualitative attributes: presence of Fuchs' dystrophy, intraoperative complications and angle closure configuration.

Results

Groups characteristics

In the study group 16 of 50 patients (32%) anterior segment fellow eyes slit lamp examination disclose Fuchs' dystrophy attributes, but only one patients history states this diagnosis before cataract surgery. Acute angle closure attack history before surgery was found in 9 patients (18%). Intraoperative complication occurred in 21 patients (42%). Two of mentioned above states (FD and AACG, FD and COMPL, COMPL and AACG) appeared in 7 patients, and none of them in 11 patients (Fig. 1).

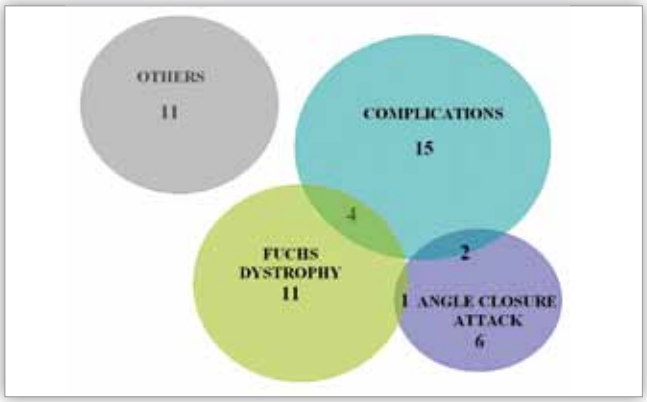

Fig. 1. Study group structure.
Ryc. 1. Struktura grupy badanej.

Cataract surgery was performed by extracapsular technique in 27 patients (56%) and by phacoemulsification in 23 patients (46%). In complication subgroup in 5 patients intraocular lens (IOL) was implanted in ciliary sulcus, in 11 patients in anterior chamber and in 5 patients eyes were left aphakic due to capsular damage/vitreous loss. In this group there were postoperative complications in 11 patients (inflamation, infection, consecutive glaucoma, retinal detachment) and in 9 patients additional surgeries were needed (vitrectomy, antiglaucoma operation, IOL explantation, secondary IOL implantation).

In 50 patients of the control group there was no Fuchs' dystrophy and 2 passed acute angle closure attack. All surgeries were phacoemulsifications, in 2 of them capsular bag was damaged and the IOL was implanted in the ciliary sulcus.

Age distribution was similar in both groups with no statistic difference (mean 74.4 *vs.* 71.4 years, t test, $p = 0.064$).

Morphometric parameters analysis

In ACD and ACAW analysis data distribution was not normal in all studied groups and subgroups. Therefore in statistic comparisons nonparametric U Mann-Whitney test was used.

ACD and ACAW study group comparisons statistically differed very significant with p values <0.0001 (Tab. I). ACD and ACAW analyses of subgroups with excluded preoperatively existing endothelial dysfunction (without FD – 41 patients left,

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Parameters/ Parametry	Study group mean or median/ Średnia lub mediana grupy badanej	Control group mean or median/ Średnia lub mediana grupy kontrolnej	Tests/ Testy
ACD	2.25 mm median	2.68 mm median	p = 0.0000006 U-test
ACAW	19.20° median	33.00° median	p = 0.000001 U-test
ACW	11.40 mm mean	11.77 mm mean	p = 0.001 t-test
TL	22.26 mm median	22.53 mm median	p = 0.18 U-test
CCT	559.40 μm mean	536 μm mean	p = 0.013 t-test

Tab. I. Parameters and outcomes in groups comparisons.
Tab. I. Parametry i wyniki porównania grup.

Parameters in subgroups/ Parametry w podgrupach	Study subgroup median/ mediana podgrupy badanej	Control subgroup median/ mediana podgrupy kontrolnej	U Test/ Test U
ACD without AACG	2.30 mm	2.70 mm	p = 0.0005
ACAW without AACG	22.50°	33.50°	p = 0.00001
ACD without FD	2.26 mm	2.68 mm	p = 0.00013
ACAW without FD	19.20°	33.00°	p = 0.000005
ACD without AACG and FD	2.37 mm	2.70 mm	p = 0.01
ACAW without AACG and FD	24.80°	33.00°	p = 0.0006
ACD: FD	2.17 mm	2.68 mm	p = 0.00063
ACAW: FD	15.50°	33.00°	p = 0.00009
ACD: COMPL	2.26 mm	2.68 mm	p = 0.00024
ACAW: COMPL	22.50°	33.00°	p = 0.00002

Tab. II. Parameters and outcomes in subgroups comparisons.
Tab. II. Parametry i wyniki porównania podgrup.

without AACG – 34 patients left and without FD and AACG – 26 patients left), revealed statistical significance with $p<0.01$ (Tab. II). In subgroups with predisposing states (with FD and with COMPL) differences in ACD and ACAW comparisons were also very significant with $p<0.001$.

Empirical data were registered in quantitative attributes coordinates ACD vs. ACAW with consideration of qualitative attributes: presence of Fuchs' dystrophy, complications and angle closure configuration. The diagram analysis showed shallow anterior chamber configuration (ACD<2.0 mm and ACAW<15°) for 12 patients (24%) of the study group and for 2 patients (4%) of the control one. Within values of 2.5 mm ACD and 25° ACAW there was also similar proportion of patients in both groups: 32 patients (64%) in study *vs.* 5 patients (10%) in control (Fig. 2, Tab. III). It reveals 6 times frequent incidence of PCE / ACE in patients small anterior chamber eyes.

Odds ratio (OR, chance quotient) is a proportion of likelihood to encounter the exposure in study group divided by proportion of likelihood to encounter the exposure in control group and shows the connection between exposure and illness. Calculated odds ratio for the PCE/ACE development in eyes with ACD<2.5 mm and ACAW<25° proved 16 times greater probability of this complication incidence in the study group (Tab. III).

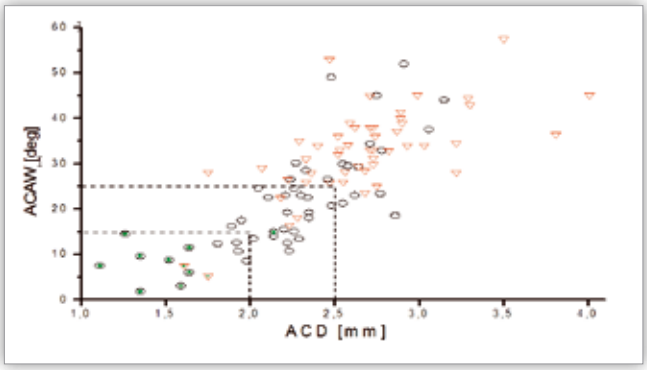

Fig. 2. Multifactorial diagram: black ring – study group, red triangle – control group, green dot – angle closure glaucoma attack history.
Ryc. 2. Diagram wieloczynnikowy: czarne kółko – grupa badana, czerwony trójkąt – grupa kontrolna, zielona kropka – przebyty ostry atak jaskry.

$$OR = \frac{32/50 : 18/50}{5/50 : 45/50} = 16.2$$

PCE/ ACE	ACD < 2,5 mm and ACAW < 25		
	YES/ TAK	NO/ NIE	TOTAL/ RAZEM
YES (study group)/ TAK (grupa badana)	32	18	50
NO (control group)/ NIE (grupa kontrolna)	5	45	50
TOTAL/ RAZEM	50	50	100

Tab. III. Small anterior chamber dimension and PCE/ACE development (odds ratio calculation).
Tab. III. Małe wymiary przedniej komory a rozwój rzekomosoczewkowego/ bezsoczewkowego obrzęku rogówki (obliczenie ilorazu szans).

Figure 3 and 4 shows tendency to FD and COPML patients occurrence in the diagram range of shallower ACD and narrower ACAW.

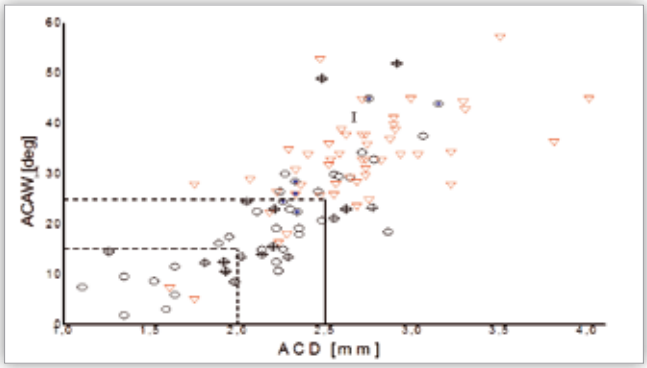

Fig. 3. Multifactorial diagram: black ring – study group, red triangle – control group, + Fuchs' dystrophy, blue dot – pseudoexfolition syndrome.
Ryc. 3. Diagram wieloczynnikowy: czarne kółko – grupa badana, czerwony trójkąt – grupa kontrolna, + dystrofia Fuchsa, niebieska kropka – zespół pseudoeksfoliacji.

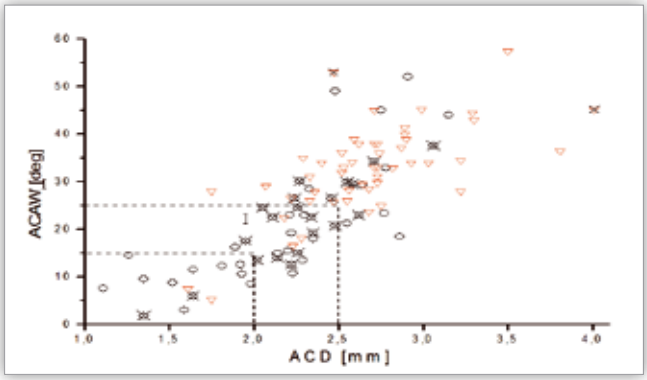

Fig. 4. Multifactorial diagram: black ring – study group, red triangle – control group, x intraopertive complications.
Ryc. 4. Diagram wieloczynnikowy: czarne kółko – grupa badana, czerwony trójkąt – grupa kontrolna, x powikłania śródoperacyjne.

Anterior chamber width analysis proved statistically significant difference in groups comparison (Tab. I).

Morphometric data of anterior segment revealed 31 patients (62%) with relative anterior microphthalmos (RAM) in study group and 17 patients (34%) in control one. ACD and ACAW comparisons in these subgroups showed statistically significant differences in nonparametric tests, while ACW and TL comparisons in RAM subgroups were insignificant (Tab. IV). The incidence of FD and complication in RAM study subgroup was similar to the rates in whole study group (36% and 42% respectively), in spite the incidence of AACG was more frequent in RAM study subgroup: 26% *vs.* 18% in whole group.

Parameters in RAM subgroups/ Parametry w podgrupach RAM	RAM study subgroup median/ Mediana badanej podgrupy RAM	RAM control subgroup median/ Mediana kontrolnej podgrupy RAM	U test/ U test
ACD:	2.14 mm	2.56 mm	$p = 0.01$
ACAW:	16.20°	29.10°	$p = 0.006$
ACW:	11.06 mm	11.24 mm	$p = 0.32$
TL:	22.02 mm	22.49 mm	$p = 0.27$

Tab. IV. Relative anterior microphthlmos subgroups comparisons.
Tab. IV. Porównanie podgrup względnego przedniego małoocza.

The difference in total axial length comparison by nonparametric U test was insignificant (Tab. I). In the intraoperative complication subgroup TL difference in comparison to control group was also insignificant (U test, $p = 0.32$).

Central corneal thickness was higher in the study group (mean 559.40 μm *vs.* 536 μm), and the difference was statistically significant (Tab. I). Analysis of the subgroup created of 34 patients without Fuchs' dystrophy (mean 545 μm) showed no difference comparing to control group (t test, $p = 0.34$). In the Fuchs' dystrophy subgroup (16 patients) mean CCT was 590 μm.

Discussion

Postoperative irreversible cornea decompensation is a serious complication strongly decreasing vision. The cataract surgeon awareness of the possible late consequences of performed procedure is of primary importance. There are known risk factors of preoperatively reduced corneal endothelial cell density. They include primary endothelial disorders and infectious or inflammatory corneal diseases, angle-closure glaucoma (esp. after acute angle closure attacks) (2,3), psedoexfoliation syndrome (4,5), ocular trauma and intraocular surgery (6,7), nuclear cataract grade V in Emery-Little scale (8-10), contact lens wearing (10). In such conditions the risk of PCE development can be higher (11). Preoperative diagnosis of these states is crucial to satisfactory long-term results of cataract surgery.

The study shows the importance of small anterior segment dimensions as a concurrent factor influencing PCE/ACE development. Presented analyses and diagrams show statistically very significant differences in ACD, ACAW and ACW (Tab. I), which indicate predisposition to this complication in eyes with small anterior chamber volume with OR = 16. Subgroup analysis with exclusion of patients with recognized preoperative pre-

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disposing factors (AACG and FD) also demonstrates statistically significant differences in ACD and ACAW (Tab. II). Moreover we have found susceptibility to intraoperative complication incidence in small anterior chamber eyes based on the statistically significant difference in the comparison the complication subgroup to control one ($p<0.0003$). In the Fuchs' dystrophy subgroup analysis anterior chamber dimensions are also smaller and reveal statistically significant differences compared to the control group (Tab. II). So we state there is anterior chamber volume influence on the endothelial cell loss during cataract surgery. However subsequent corneal decompensation is often connected with preoperative occurrence of states with poor endothelial reserve or intraoperative complications.

These results, in connection with statistically significant differeces in ACW, suggest higher incidence of relative anterior microphthalmos (RAM) in the study group. This term, coined by Naumann in 1980, describes an eye with normal axial length (>20 mm) (1), but disproportionately small anterior chamber (white-to-white horizontal corneal diameter <11 mm) with normal anatomical appearance. In the study of Goldsmith et al. (12) mean measurements of white-to-white corneal diameter with caliper were 0.75 mm smaller compared to ACW obtained by Visante OCT. On the basis of this differences we took border ACW measurement of 11.5 mm. Comparing ACD and ACAW of RAM patients we found smaller anterior chamber dimensions in study subgroup (Tab. IV) with more frequent AAGC incidence. On the basis of our study we agree with Auffarth et al. (13) statement of the importance of the preoperative identification of RAM patients in order to prevent serious complications during and after cataract surgery and Nihalani et al. (14) suggestion of preoperative ACD measurement necessity.

Corneal thickness is an indirect but sensitive index of the endothelium functioning. Preoperative measurements esp. in early stages or suspicion of Fuchs' dystrophy often reveals subclinical edema. In our CCT analysis thicker corneas appear in study group what is due to higher CCT in patients with Fuchs' dystrophy. After exclusion of these patients from the study group there was no statistic difference in comparison. In Insler's et al. (15) research of CCT in the fellow eye of patients with PCE the difference in mean CCT in comparison to control group was even higher: 572 μm *vs.* 514 μm. The history of the subgroup of 16 patients with Fuchs' dystrophy reveals very rare preoperative diagnosis of early stages of this disease: only one person was diagnosed before cataract operation.

We have not found similar analysis of the morphometric data of the anterior chamber in connection with PCE/ACE development in available literature. The study of Walkow et al. (10) states short axial length as a risk factor of higher endothelial cell loss during cataract surgery but he did not found such correlation in eyes with shallower anterior chamber. In our patients data axial length was also shorter in the study group but difference was not statistically significant.

Limitation of our study is retrospective analysis method, but in case of very rare disorder it appears to us to be justified. Morphometric data of fellow eye we found representative for preoperative state of PCE/ACE eye with consideration of exclusion criteria eliminating possible asymmetric states. In spite of the mentioned above limitations, we are convinced that the idea of our study is appropriate in the event of so rare as well as delayed onset postoperative complication. Being aware of complexity of PCE/ACE development and its causes with great influence of the intraoperative course, we found the fellow eye examination giving a lot of important informations and being the clue in searching ex post the possible cause of corneal decompensation. We have not found in the literature any surgical factor that could explain so significant endothelial cells loss leading to corneal edema under condition of performing surgery without complication. The reason could be small number of analyzed cases in studies of surgically induced endothelial cell loss compared to rare PCE incidence and shallow anterior chamber configuration in population. The prospective study evaluating direct influence of anterior chamber dimensions on endothelial cell density after cataract surgery would be very informative.

In conclusion small anterior chamber and thicker cornea due to Fuchs' dystrophy are risk factors of PCE/ACE development. Preoperative evaluation of anterior segment morphometry is crucial in proper cataract surgery planning in order to anticipate and prevent intra- and postoperative complications.

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