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ORIGINAL PAPER

The evaluation of the risk factors for capsular complications in phacoemulsification

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Abstract
Purpose To determine and quantify the risk factors for disruption of lens capsule integrity during phacoemulsification.
Methods The medical records of the patients who had undergone phacoemulsification cataract surgery and had a complication associated with lens capsule were reviewed. Consecutive cases were also reviewed in reverse chronological order as a control group. The exclusion criteria were pediatric cataracts, traumatic cataracts and lens dislocation. As a result, 403 uncomplicated and 83 complicated eyes were analyzed. The differences between the complication group and the group without complications regarding the risk factors were shown by employing the Chi-square test and Fischer's exact test. The variables having the level of significance ($p < 0.25$) after the Chi-square test and Fischer's exact test were enrolled into the multiple stepwise logistic regression analysis.
Results Age (60–69/≤80) ($p = 0.017$), male gender ($p = 0.006$), pupil size ≤3 mm ($p = <0.001$), mature–brunescent cataract ($p = <0.001$), anterior chamber depth <2.5 mm ($p = 0.001$), posterior polar cataract ($p = 0.006$), diabetic retinopathy($p = <0.001$), coronary artery disease ($p = 0.098$) and surgeon factor (junior resident/senior resident, $p = 0.015$; senior resident/specialist in ophthalmology, $p = 0.026$; junior resident/specialist in ophthalmology, $p = 0.020$) were among the factors significantly related to a capsule complication. An Excel program has been developed according to these results to predict the probability of capsule complication.
Conclusions Higher-risk cases can be predicted preoperatively, thus allowing surgeons to take appropriate precautions, better informing the patient and better selecting the cases especially for trainee surgeons.

Keywords Lens capsule integrity · Phacoemulsification · Posterior capsular rupture · Risk factors

Introduction

Posterior capsule rupture (PCR) is one of the most frequently encountered and serious intraoperative

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complications of phacoemulsification surgery [1, 2]. PCR is an undesirable and bothersome complication as it may lead to additional surgical interventions, postoperative complications and eventually a deterioration in the final visual acuity.

Preoperatively, having a quantitative parameter about the probability of anterior capsular tear and PCR makes it possible to determine the adversity of a case, thus providing more exact information about the possible risks of the operation to the patients. Besides that, it makes it easy to decide which resident can handle the operation in ophthalmology training clinics. Also a surgeon may want to send a challenging case to a more experienced surgeon by referring a quantitative risk score. Additionally, it may serve as an objective criterion for comparing the operations and surgeons.

In this study, we aimed to evaluate the factors that might affect the integrity of the lens capsule during the phacoemulsification and also to design a formula with which the probability of a capsular complication can be easily calculated.

Methods

In the first step, 83 cases with capsular complications during phacoemulsification at Ankara Atatürk Training and Research Hospital were enrolled into the study. Capsular complication was defined as: peripheral extension of continuous curvilinear capsulorrhexis and/or needing an extracapsular cataract extraction surgery, and PCR. According to the power analysis, the number of cases, which must be included in the study with a 5% level of significance and 80% power, was found to be >400. Thus, 403 consecutive cases that had undergone phacoemulsification surgery without complication were enrolled. The exclusion criteria were pediatric cataracts, traumatic cataracts and lens dislocation. Four patients who had undergone an intraocular surgery other than vitrectomy were excluded in order to maintain the group homogenization due to their few number. Nine patients having lack of some medical records were also excluded. The age, gender and the systemic diseases of the patients including diabetes mellitus (DM), hypertension (HT) coronary artery disease (CAD) and asthma were noted. The details of ophthalmic examinations consisting of distance corrected visual acuity (DCVA), axial length (AL) (E-Z Scan AB5500, Sonomed, USA), anterior chamber distance (ACD), (E-Z Scan AB5500, Sonomed, USA), pupil size (PS), type of cataract, accompanying ocular diseases (corneal opacity, pseudoexfoliation, phacodonesis, glaucoma, diabetic retinopathy, senile macular degeneration (SMD), vitreous opacity and vitrectomized eye), hollow-eyed and one-eyed patients (if the visual acuity was less than counting fingers at 1 m) were recorded. The information about the laterality, other eye's phacoemulsification history, type of anesthesia and the surgeon was also noted. The surgeons were grouped as ophthalmologists who were specialized in cataract and refractive surgery (CRS), ophthalmologists who were not specialized in CRS, senior residents and junior residents who had performed less than 50 phacoemulsification surgery. All of the surgeries were performed with Infinity (Infinity Vision Systems, Alcon Laboratories Inc., Fort Worth, TX, USA) and Accurus 800CS (Cataract Surgical Unit, Alcon Laboratories, Kentucky, USA).

Statistics

Quantitative variables were represented with numbers or percentage. The differences between the complication group and the group without complications regarding the risk factors were shown by employing the Chi-square test and Fischer's exact test. The differences between the quantitative risk factors were determined with the independent t test. The variables having the level of significance ($p < 0.25$) after the Chi-square test and Fischer's exact test were enrolled into the multiple stepwise logistic regression analysis. In the regression model, the criteria for entering the model was determined as $p < 0.05$ and the exit criteria was $p > 0.10$. The Hosmer–Lemeshow test was used in order to check the goodness of fit for the final model of logistic regression analysis. DCVA variables were converted into logMAR, and the best cutoff point of DCVA between the two groups was calculated using the ROC curve.

SPSS (Statistical Package for Social Science) for Windows version 15.0 was employed in statistical analysis.

Results

The complication group was consisted of 83 eyes of 80 patients, and the normal group was consisted of 403

Table 1 General characteristics of the patients (number: 392)

	Number	%
Age		
<60	106	27.0
60–69	109	27.8
70–79	129	32.9
80–89	44	11.2
>90	4	1.0
Gender		
Female	203	51.8
Male	189	48.2
DM[a]	126	32.1
HT[b]	186	47.4
CAD[c]	57	14.5
Asthma	19	4.8
Alpha blocker use	11	2.8

[a] Diabetes
[b] Hypertension
[c] Coronary artery disease

eyes of 312 patients. Of these 392 patients, 203 were female (51.8%) and 189 were male (48.2%). The characteristic properties of the patients are shown in Table 1.

The complication group and the normal group were compared with Chi-square test and Fischer's exact test regarding the risk factors. Table 2 shows the general characteristics of the groups. Gender and HT were statistically different between the groups ($p = 0.019$ and $p = 0.015$, respectively). Although there was high complication rate in 60–69 age group and low complication rate over 80 age group, there was not a statistically significant difference and linear relationship between the age groups.

DCVA values were converted to logMAR, and the best cutoff point was found to be 0.85 according to the ROC curve (Table 3). Additionally, as DCVA values below 0.1 at Snellen lines were found to be a risk factor for capsular complications in Lundström et al.'s study, we included this value into the Chi-square test and both of these cutoff values were statistically significant between two groups ($p < 0.001$) (Table 4).

The comparison of the ophthalmologic features of two groups is detailed in Table 4. There was a statistically significant difference in PS, mature–brunescent cataract, ACD, posterior subcapsular cataract, posterior polar cataract, phacodonesis, vitreous opacity and DCVA ($p < 0.05$).

The ocular comorbidity of two groups was compared; details are shown in Table 5. Glaucoma,

Table 2 General characteristic properties of the complication group and normal group

	Normal ($n = 403$)		Complication group ($n = 83$)		p
	Number	%	Number	%	
Age					
<60	112	85.5	19	14.5	0.051
60–69	101	75.4	33	24.6	
70–79	137	85.1	24	14.9	
>80	53	88.3	6	10.9	
Gender					
Female	222	86.7	34	13.3	0.019
Male	181	78.7	49	21.3	
DM[a]					
(−)	281	84.6	51	15.4	0.140
(+)	122	79.2	32	20.8	
HT[b]					
(−)	198	78.9	53	21.1	0.015
(+)	205	87.2	30	12.8	
CAD[c]					
(−)	337	81.6	76	18.4	0.094
(+)	66	90.4	7	9.6	
Asthma					
(−)	382	82.3	82	17.7	0.148
(+)	21	95.5	1	4.5	
Alpha blocker use					
(−)	385	82.3	83	17.7	0.053
(+)	18	100.0	0	0	

[a] Diabetes
[b] Hypertension
[c] Coronary artery disease

Table 3 ROC curve analysis of distance corrected visual acuity

Area under the curve (AUC)	667
p	0.032
Cutoff	0.85
Sensitivity of the cutoff point	62.7%
Specificity of the cutoff point	63%

Table 4 Ophthalmological properties of the groups

	Normal ($n = 403$)		Complication group ($n = 83$)		p
	Number	%	Number	%	
Corneal opacity					
(−)	391	83.2	79	16.8	0.495
(+)	12	75.0	4	25.0	
Pupil size					
<3 mm	391	85.7	65	14.3	<0.001
≤3 mm	12	40.0	18	60.0	
Mature–brunescent					
(−)	352	86.7	54	13.3	<0.001
(+)	51	63.8	29	36.3	
AL[a]					
20–26 mm	382	83.2	77	16.8	0.435
≤26 mm	21	77.8	6	22.2	
ACD[b]					
≤2.5 mm	394	85.1	69	14.9	<0.001
<2.5 mm	9	39.1	14	60.9	
PSC[c]					
(−)	271	80.4	66	19.6	0.038
(+)	132	88.6	17	11.4	
PPC[d]					
(−)	395	83.7	77	16.3	0.020
(+)	8	57.1	6	42.9	
Pseudoexfoliation					
(−)	360	83.7	70	16.3	0.268
(+)	43	76.8	13	23.2	
Phacodonesis					
(−)	403	84.5	74	15.3	<0.001
(+)	0	0	9	100.0	
DCVA					
>0.1	261	89.1	32	10.9	<0.001
<0.1	142	73.6	51	26.4	
Hollow eye					
(−)	391	83.2	79	16.8	0.495
(+)	12	75.0	4	25.0	
Single eye					
(−)	392	83.4	78	16.6	0.167
(+)	11	68.8	5	31.3	
Vitreous opacity					
(−)	389	83.8	75	16.2	0.036
(+)	14	63.6	8	36.4	
DCVA[e] logMAR					
<0.85	254	89.1	31	10.9	<0.001
≥0.85	149	74.1	52	25.9	

[a] Axial length

[b] Anterior chamber depth

[c] Posterior subcapsular cataract

[d] Posterior polar cataract

[e] Distance corrected visual acuity

diabetic retinopathy and vitrectomized eye were statistically significant between the groups ($p = 0.006$, $p < 0.001$, $p = 0.002$, respectively).

Comparison of the details about the surgery of the groups are shown in Table 6. Only history of complication in the other eye had a statistically significant difference between the two groups ($p = 0.018$). The surgeon group in which the complication was mostly seen was the junior residents group, and the least complication was seen in the senior residents group. However, there was not a linear relationship and a statistically significant difference among the groups.

Table 5 Ocular comorbidity of the groups

	Normal ($n = 403$)		Complication group ($n = 83$)		p
	Number	%	Number	%	
Glaucoma					
(−)	387	84.1	73	15.9	0.006
(+)	16	61.5	10	38.5	
Diabetic retinopathy					
(−)	372	86.1	60	13.9	<0.001
(+)	31	57.4	23	42.6	
Vitrectomized eye					
(−)	401	83.7	78	16.3	0.002
(+)	2	28.6	5	71.4	
SMD[a]					
(−)	380	83.0	78	17.0	0.801
(+)	23	82.1	5	17.9	

[a] Senile macular disease

Table 6 Surgical properties of the groups

	Normal ($n = 403$)		Complication group ($n = 83$)		p
	Number	%	Number	%	
Laterality					
Right	213	83.2	43	16.8	0.862
Left	190	82.6	40	17.4	
Surgery rank					
1	261	82.1	57	17.9	0.495
2	142	84.5	26	15.5	
Anesthesia					
Subconjunctival	232	83.8	45	16.2	0.432
Subtenon	145	80.6	35	19.4	
Topical	16	94.1	1	5.9	
General	1	50.0	1	50.0	
Retrobulbar	9	90.0	1	10.0	
Surgeon					
CRS[a] specialist	87	79.1	23	20.9	0.071
Specialist in ophthalmology	152	82.6	32	17.4	
Senior resident	119	89.5	14	10.5	
Junior resident	45	76.3	14	23.7	
Complication history in the fellow eye					
(−)	400	83.5	79	16.5	0.018
(+)	3	42.9	4	57.1	

[a] Cataract and refractive surgeon

As a result, the variables that had a statistically significant difference were: age, HT, PS, mature–brunescent cataract, ACD, posterior subcapsular cataract, posterior polar cataract, phacodonesis, glaucoma, diabetic retinopathy, DCVA, history of complication in the fellow eye, vitreous opacity and vitrectomized eye. Additionally, variables having $p < 0.25$ (age, diabetes and surgeon) were included in the multiple logistic regression analysis due to statistical reasons. Phacodonesis, history of complication in the fellow eye, asthma, vitrectomized eye, alpha blocker medication, single eye were not included as they were too few for a reliable logistic regression analysis.

The results of the multiple logistic regression analysis are shown in Table 7. The overall correctness of the model was 87%, and the result of Hosmer–Lemeshow goodness of fit was $p = 0.922$.

The variables, which gained significance with the stepwise selection method, are shown in Table 8. Age, gender, PS, mature–brunescent cataract, ACD, posterior polar cataract, diabetic retinopathy, surgeon and CAD were included in the last model.

There was not a linear relationship among the age groups. 60–69 age group was 1962× riskier than 70–79 age group and 3966× riskier than over 80 age group ($p = 0.068$ and $p = 0.017$ respectively). There was not any statistically significant relationship among the other groups (Table 8).

The complication risk was 2275× more in males, 11,843× more when PS < 3 mm, 4949× more in mature–brunescent cataract, 6084× more when ACD < 2.5 mm, 7111× more in posterior polar cataract, 4371× more in diabetic retinopathy, 2197× more in CAD (Table 8).

There was not a linear relationship among the groups regarding the surgeon. Nevertheless, junior residents were 2482×, 3148× and 2793× riskier than specialist in CRS, senior residents and specialists in ophthalmology, respectively ($p = 0.057$, $p = 0.015$, $p = 0.020$). Senior residents were 2680× more risky than specialist in ophthalmology ($p = 0.026$) (Table 8).

The overall correctness of the last model was 86.6%, and the result of Hosmer–Lemeshow goodness of fit was $p = 0.208$.

The probability of complication can be calculated with the formula below according to the logistic regression model.

Complication risk = exponent (−3112 + (60–69 age) × 0.628 + (70–79 age) × −0.046 + (over 80) × −0.750 + gender × 0.822 + PS × 2472 + MB × 1599 + ACD × 1806 + PPC × 1962 + DR × 1475 + junior resident × 0.909 + senior resident × −0.238 + specialist in ophthalmology × −0.078 + CAD × −0.788)/(1 + exponent−3112 + (60–69 age) × 0.628 + (70–79 age) × −0.046 + (over 80) × −0.750 + gender × 0.822 + PS × 2472 + MB × 1599 + ACD × 1806 + PPC × 1962+ DR × 1475 + junior resident × 0.909 + senior resident × −0.238 + specialist in ophthalmology × −0.078 + CAD × −0.788)).

Age = Patient's age group is 1, others are 0.
Gender = Male is 1, female is 0.
PS = If pupil size > 3 mm, then 0; if PS ≤ 3 mm, then 1.
MB = If mature–brunescent cataract exists, then 1; if not 0.
ACD = If ACD < 2.5 mm, then 1, if ACD ≥ 2.5 mm, then 0.

Table 7 Outcomes of the multiple logistic regression analysis of variables

	β	Expβ (odds ratio)	95% Limit of agreement for the odds ratio	p
Age (all)				0.028
Age (<60/80 over))	1.009	2.744	0.808–9.313	0.106
Age (60–69/80 over)	1.664	7.567	1.614–17.293	0.006
Age (70–79/80 over)	0.897	2.453	0.780–7.715	0.125
Gender (male/female)	0.729	2.074	1.131–3.801	0.018
DM[a]	−0.187	0.829	0.365–1.883	0.654
HT[b]	−0.260	0.771	0.409–1.454	0.422
Pupil size (≤3 mm/<3 mm)	2.365	10.642	3.688–30.707	<0.001
Mature–brunescent	1.175	3.238	1.398–7.499	0.010
ACD[c]	1.717	5.567	1.753–17.677	0.004
PSC[d]	−0.460	0.631	0.311–1.280	0.202
PPC[e]	1.776	5.907	1.405–24.835	0.015
Glaucoma	0.757	2.131	0.709–6.408	0.178
Diabetic retinopathy	1.541	4.670	1.753–12.440	0.002
Surgeon				0.061
Surgeon (specialist in ophthalmology/specialist in CRS[f])	−0.015	0.985	0.448–2.166	0.970
Surgeon (senior resident/specialist in CRS[f])	−0.153	0.858	0.354–2.080	0.734
Surgeon (junior resident/specialist in CRS[f])	1.034	2.813	1.073–7.376	0.036
CDVA[g]	−0.017	0.983	0.063–15.346	0.990
CDVA logMAR (≥0.85/<0.859	0.474	1.607	0.107–24.160	0.732
CAD[h]	−0.670	0.512	0.193–1.358	0.179
Vitreous opacity	−0.107	0.898	0.268–3.008	0.862

[a] Diabetes

[b] Hypertension

[c] Anterior chamber depth

[d] Posterior subcapsular cataract

[e] Posterior polar cataract

[f] Cornea and refractive surgery

[g] Distance corrected visual acuity

[h] Coronary artery disease

APK = If posterior polar cataract exists, then 1; if not 0.
DR = If diabetic retinopathy exists, then 1; if not 0.
Surgeon = Surgeon's group is 1, others are 0.
CAD = If CAD exists, then 1; if not 0.

For example, a 70-year-old female patient has mature cataract. Her PS is >3 mm, and ACD is ≥2.5 mm. She is operated by a senior resident, and she does not have any systemic diseases.

$$\begin{aligned}\text{Complication risk}\\ &= \text{exponent } (-3112 + 1 \times -0.046 + 1 \times 1599 + 1 \times -0.238)/\\ &\quad \times (1 + \text{exponent } (-3112 + 1 \times -0.046 + 1 \times 1599 + 1 \times -0.238)\\ &= \text{exponent } (-1797)/(1 + \text{exponent } (-1797)) = 0.142\end{aligned}$$

The complication risk of this patient is 14%.

This formula was created in Excel for practical use. The image of the calculation above in Excel is shown in Fig. 1.

Discussion

As a consequence of the rapid improvement in phacoemulsification surgery field, the patients' expectations from the surgery results have extremely increased as well as the surgeons'. High surgical standards along with low complication rates have been achieved with the help of the advanced surgical platforms and techniques [3, 4]. Thus, managing and taking up with the complications have gradually become more difficult with this soaring quality of cataract surgery. The complications experienced during the training sessions are the other important issue of this difficulty. However, phacoemulsification, though presented as a simple procedure, is a sophisticated surgery, which requires bimanual manipulation, eye-hand-foot coordination and a great care. Moreover, each case varies in itself and has distinctive adversity. Thus, it is obvious that forming a quantitative method that gives a risk score of phacoemulsification would be useful.

The first risk scoring of cataract surgery in the literature was made by Najjar and Awwad in 2003 [5]. Muhtaseb et al. [6] reported that they formed a risk score by searching the literature in 2004. Habib et al. [7] reported about the potential adversity score they used in their study in 2004. The major disadvantage of these risk scores employed in three different clinics was the lack of any statistical methods while determining the risk factors and understanding the significance of them. On the other hand, all three of these methods were practical in clinical use. There are also studies in which the risk factors for PCR were investigated in extensive series along with these risk scaling studies [8–10].

In our study, we tried to evaluate all the factors revealed as a risk factor in analogous studies along with the three risk scoring studies. In this manner, we investigated the potential risk factors altogether, which were particularly investigated in the literature, with logistic regression analysis, which considers the relationship of all risk factors among themselves. As a result, we acquired the odds ratios of the risk factors which showed the effect of the risk factors in complication occurrence. Also, we managed to show the possibility of generating a risk scoring system based on a reliable statistical study.

After the evaluation of so many risk factors, remaining variables in the final statistical model were age, gender, pupil size, mature or brunescent cataract, anterior chamber distance, posterior polar cataract, diabetic retinopathy, surgeon and coronary artery disease. These factors are discussed in depth below.

The general opinion is that the capsule gradually becomes more inclined to be ruptured with aging. Therefore, we examined the age variable, which was found to be a risk factor for complicated cataract surgery in some studies. The age group in which the complication mostly seen was 60–69 group, and interestingly, the least complication was seen in over 80 age group. However, there was not a linear relationship between the age groups and the differences were not statistically significant ($p = 0.051$) (Table 2). We thought that the outcomes about the age were coincidental as there was not a linear relationship, and the only significant difference, which was expected to be a reverse result, was between 60 and 69 and over 80 age groups in the final statistical model. The unexpected result for the over 80 age group might be caused by the small size of the group, and by the fact that they were mostly the early cases of the day. Early cases of the day may be advantageous in terms of complication, because the surgeon is certainly more fresh and the stress level of the patient is not increased as she does not have to wait for too long during the day. In this respect, we suggest that considering how many cases the surgeon performed beforehand in the day and the time of surgery in future studies may be useful for investigating the risk factors for phacoemulsification.

Male gender was found to be a risk factor for cataract surgery in a study consisting of very large series [9]. Our findings were also in agreement with this study. We found that male gender is 2.275-fold riskier than female gender for encountering a capsular complication according to our final regression model (Table 8). Nevertheless, the reason of this difference has not been investigated yet. The different effects in cardiovascular system due to hormonal factors, personality structure, the effects of alpha blockers may lead to this different outcome between the genders.

Patients having pupil size <3 mm were found to encounter 11,843× more complication in comparison with the patients having PS > 3 mm, and this was the most robust risk factor among the others. This is a well-known risk factor showed by the previous studies [9, 11]. Making manipulations in the invisible region,

Table 8 Multiple stepwise logistic regression analysis of variables

	β	Expβ (odds ratio)	95% Limit of agreement for odds ratio	*p*
Age (all)				0.067
Age (60–69/<60)	0.628	1.874	0.881–3.982	0.103
Age (70–79/<60)	−0.046	0.955	0.445–2.051	0.906
Age (≤80/<60)	−0.750	0.472	0.147–1.517	0.208
Age (60–69/70–79)	0.674	1.962	0.952–4.045	0.068
Age (60–69/≤80)	1.378	3.966	1.277–12.322	0.017
Age (70–79/≤80)	0.704	2.022	0.665–6.148	0.215
Gender (male/female)	0.822	2.275	1.266–4.088	0.006
Pupil Size (≤3 mm/<3 mm)	2.472	11.843	4.152–33.779	<0.001
Mature–brunescent	1.599	4.949	2.493–9.824	<0.001
ACD[a] (<2.5 mm/≤2.5 mm)	1.806	6.084	2.005–18.459	0.001
PPC[b]	1.962	7.111	1.757–28.787	0.006
Diabetic retinopathy	1.475	4.371	2.027–9.425	<0.001
Surgeon				0.077
Surgeon (specialist in ophthalmology/specialist in CRS[c])	−0.078	0.925	0.428–1.997	0.842
Surgeon (senior resident/specialist in CRS[c])	−0.238	0.788	0.334–1.864	0.588
Surgeon (junior resident/specialist in CRS[c])	0.909	2.482	0.973–6.329	0.057
Surgeon (junior resident/senior resident)	1.147	3.148	1.253–7.910	0.015
Surgeon (senior resident/specialist in ophthalmology)	0.987	2.680	1.124–6.410	0.026
Surgeon (junior resident/specialist in ophthalmology)	1.027	2.793	1.176–6.623	0.020
CAD[d]	−0.788	0.455	0.179–1.158	0.098

[a] Anterior chamber depth

[b] Posterior polar cataract

[c] Cornea and refractive surgery

[d] Coronary artery disease

inside the capsular bag behind the iris, induces increased complication ratios in small pupils [12]. Additionally, it is known that factors that lead to a small pupil, like PEX, also are themselves risk factors for the capsular complications along with the PS.

Previous studies showed that problems with the capsulorhexis and PCR were more frequently encountered in white-mature cataracts [13–15]. We did not include the grading of nuclear sclerosis as the grading system is subjective and varies among the clinics. However, diagnosing a white-mature cataract is very objective; therefore, we included it as a variable and found that it was a risk factor for capsular complications as confirmed by the previous studies. Mature–brunescent cataract took place in our final regression model with a 4949 odds ratio (Table 8). This increased risk of complication can be explained with a few factors. The epinucleus surrounding the nucleus in mature cataracts frequently gets thinner. Additionally, following the border of capsulorhexis is more difficult and manipulations for cracking the nucleus may rupture the capsule or lead to the zonular damage.

Anterior chamber depth was not included in the two large data-based studies which investigated the preoperative risk factors for PCR [8, 9]. Although our number of cases was smaller, this was a single center study, involving ACD as an independent variable was one of the major advantages of our study. As expected from the previous similar studies [16, 17], we found that ACD < 2.5 mm has 6084× more risk of complication in comparison with ACD > 2.5 mm (Table 8).

The regression analysis showed that eyes with posterior polar cataract encountered 7111× more complication than the eyes with other types of cataract (Table 8). It was not a very surprising outcome since it is known that PCR rates are between 26 and 40% in

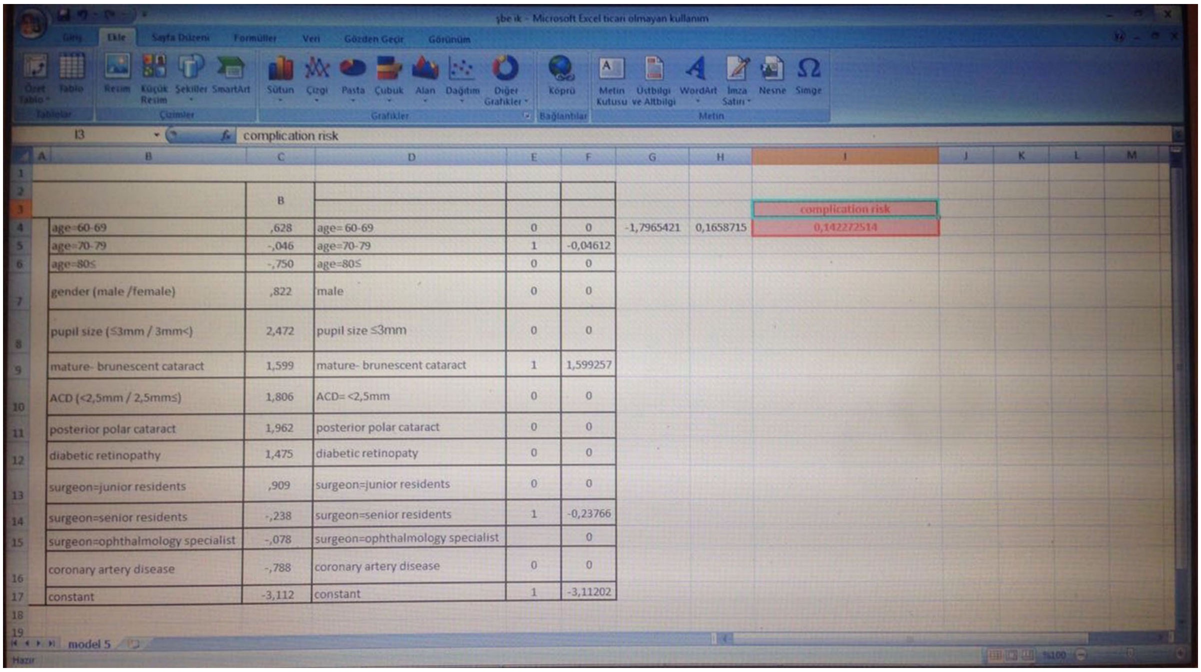

Fig. 1 Calculation of the risk complication of a patient in Excel

eyes with posterior polar cataract [18, 19]. This high complication rate in posterior polar cataracts arises from the weakness and the fragility of the lens capsule and moreover from the lacking capsule at the site of the opacity in some cases [20].

To the best of our knowledge, our study is the first study which enrolls diabetes and diabetic retinopathy together when investigating the preoperative risk factors for phacoemulsification. Despite the fact that the complication rates were higher in patients with diabetes, there was not a statistically significant difference ($p = 0.140$). However, diabetes variable was included in the logistic regression analysis due to its $p < 0.25$. Diabetic retinopathy was included with a statistically significant difference ($p < 0.001$). Diabetes did not gain significance as a result of stepwise analysis ($p = 0.654$) (Table 7). In conclusion, while diabetes had not any effect on complication rates, having diabetic retinopathy was found to be 4371× riskier than not having diabetic retinopathy as confirmed by previous similar studies [7, 8, 10, 21]. It was shown that cataract surgery could accelerate the progression of the disease in prominent diabetic retinopathy, while it did not have that type of effect in minimal diabetic retinopathy [22, 23]. Therefore, our study outcomes support the suggestion of surgery in early stages of the cataract in diabetic patients for the stability of the retinopathy as well as for a low risk cataract surgery.

The high complication rates of the specialists of CRS found in our study can be explained with the fact that they usually operate the most troublesome cases in our center. In here, the benefit of the logistic regression analysis can be understood more obviously as follows. As the probable risk factors were enrolled into the regression model, the influence of high complication rates disappeared in the model. Hereby, being a specialist in CRS did not increase the complication risk among the other groups despite the high complication rates. Besides, the risk of a junior resident was 2482×, 2793× and 3148× higher in comparison with a specialist in CRS, a specialist in ophthalmology and senior residents, respectively ($p = 0.057$, $p = 0.020$, $p = 0.015$, respectively). Additionally, the risk of a senior resident was 2680× higher in comparison with the risk of a specialist in ophthalmology and it was also statistically significant ($p = 0.026$). There are studies in the literature, which show that as the number of operations performed increases, the complication rates decrease [24, 25].

CAD was not included in the studies in which the preoperative risk factors for cataract surgery were investigated previously. Anticoagulant and antiplatelet drug use was studied by Blumquist et al. [10], and it was shown that they were not risk factors. In our study, surprisingly, it was found that CAD had a 2197 odds ratio. When we investigated this result thoroughly, we observed that the same operation conditions were available for cases with CAD like the cases over age 80. Thus, we suggest that enrolling the CAD along with the ranking of the case within the day into similar following studies would detect if these two factors, separately or together, are risk factors for cataract surgery. The antiaggregant therapy may induce complications by mechanisms we do not know yet. We think that the effect of the antiaggregant therapy on zonules, anterior chamber stability and lens structure should be investigated on the molecular basis.

While there are not so many studies evaluating a lot of risk factors together, there are so many studies evaluating a few factors. Although investigating the risk factors individually is important, studies evaluating the effect of the factors among themselves are essential. Therefore, we enrolled so many probable risk factors together, which were examined in previous studies and additionally, we also evaluated the potential risk factors that were noted in our medical records. To the best of our knowledge, our study is the first to evaluate such a high number of risk factors together in the literature. Multiple stepwise logistic regression analysis, which we employed in our study, evaluates so many variables considering the relations between them. Therefore, even a recently added weaker variable can affect the results. Thus, the major advantage of our study was investigating so many factors by employing the multiple stepwise logistic regression analysis. In this manner, we evaluated the potential risk factors in cataract surgery with phacoemulsification in detail.

The major disadvantage of our study was the number of cases. Actually, the number of cases, as explained in Methods section, was sufficient for the design of the study and feasibility of the analysis. However, we had to exclude some variables as they were only a few due to their distribution in the study groups. Although this exclusion did not reduce the value of the obtained risk factors, it reduces the reliability of the risk scoring. However, our first and major goal was to determine the possible risk factors and our second goal was to show the possibility of generating a practical scoring system, not to generate an excellent scoring system. Therefore, we formed a practical risk scoring system in Excel with employing the obtained risk factors.

Forming a risk scoring system with the obtained risk factors may have some advantages. It may provide the proper surgeon to operate the proper case especially in ophthalmology training clinics; thus, it may help to decrease the complication rates. However, it was stated that if the challenging cases were always operated by the experienced surgeons, then an inexperienced surgeon would never gain experience [26]. This problem can be solved by giving close attention when comparing the surgeon's case number, skills and the adversity of the case.

The risk scoring system may also be helpful when talking with the patients about the possible risks of the surgery preoperatively. If a quantitative risk is shared with the patient, then her expectations would be more realistic; as a result, her compliance with the result would be much better after a probable complication.

Scoring systems may lead to a more objective and unbiased evaluation of the results of the surgeons. We cannot compare the complications or surgery time of a surgeon who usually performs a lot of surgeries having average adversity and a surgeon who generally performs difficult surgeries. Therefore, the cataract surgery, operation time of which even becomes an issue of discussion among the patients, requires a risk scoring system.

In conclusion, accessing the extensive series, which are necessary for determining the factors affecting the integrity of the lens capsule, is only possible if a national database is constituted. If this database comprises all the factors obtained from our study and the other studies in the literature, then an accurate logistic regression analysis can be employed. The results can be used for calculating the risk of capsular complications preoperatively, and an Excel program can be easily composed for practical clinical use.

Compliance with ethical standards

Conflict of interest Authors state that there is no conflict of interest.

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