Incidence of and risk factors for vitreous loss in resident-performed phacoemulsification surgery

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PURPOSE: To determine the incidence of and risk factors for posterior capsule rupture and vitreous loss during phacoemulsification performed by ophthalmology residents.

SETTING: Academic ophthalmology resident training center, Tehran, Iran.

DESIGN: Cross-sectional study.

METHODS: This study included patients who had phacoemulsification by ophthalmology residents from August 2010 to August 2011. The complications occurring during surgery and the rate of vitreous loss and posterior capsule rupture were studied.

RESULTS: Five hundred eyes of 500 patients, including 255 (51%) men and 245 (49%) women with a mean age of 67 years ± 10 (SD) (range 27 to 105 years), were studied. Fifty-one eyes (10.2%) developed vitreous loss, and 48 eyes (9.6%) developed posterior capsule rupture and vitreous loss. On univariate analysis, significant risk factors for vitreous loss included diabetes mellitus ($P=.001$), shallow anterior chamber ($P=.01$), absence of supervision by a faculty member ($P=.007$), larger capsulorhexis ($P=.02$), anterior capsule tear ($P=.001$), and longer effective phacoemulsification time (EPT) ($P=.003$). Multivariate data analysis using stepwise logistic regression analysis showed anterior capsule tear (odds ratio [OR], 2.63; 95% confidence interval [CI], 1.09-6.29), longer EPT (OR, 1.01; 95% CI, 1.003-1.02), and lack of supervision by attending physicians (OR, 4.28; 95% CI, 1.44-12.67) to be significant independent risk factors associated with vitreous loss.

CONCLUSION: Direct attending supervision and careful case selection for the level of cataract surgery residency are of utmost importance in avoiding sight-threatening complications.

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The goal of an ophthalmology residency program is to train future leaders in clinical and academic ophthalmology. The number of ophthalmologists in Iran is more than 1500, and there are many well-equipped ophthalmic centers throughout the country.[1] The duration of training in ophthalmology residency in Iran and some other countries is 4 years.[2] In many countries, during the first year residents typically perform extracapsular cataract extraction (ECCE). In Iran, residents begin cataract surgical training during their second year of residency using an ECCE technique, except at Farabi Eye Hospital, where residents are first taught phacoemulsification.[3]

A previous study[4] indicated that the rate of complications associated with the phacoemulsification procedure is higher in patients who were operated on by ophthalmology residents than in patients who were operated on by specialists. We performed this study to evaluate the incidence of and risk factors for posterior capsule rupture and vitreous loss during phacoemulsification performed by ophthalmology residents.

PATIENTS AND METHODS

This prospective study included all patients who had phacoemulsification for senile cataract by ophthalmology residents in Farabi Eye Hospital from August 2010 to August

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2011. The study protocol was approved by the Ethical Committee, Tehran University of Medical Sciences. The nature of the research was explained to the patients, who all signed an informed written consent form.

Preoperatively, all patients had a comprehensive eye examination including measurement of intraocular pressure, slitlamp biomicroscopy, and dilated fundus evaluation. Exclusion criteria were congenital cataract, traumatic cataract, cataract that required other intraocular surgical procedures, cataractous eyes with history of pars plana vitrectomy (PPV), and second eyes of patients in this series.

A questionnaire was prepared using data from previous studies and was completed by the investigators during surgery. The questionnaire included demographic data, information about underlying systemic and ocular conditions, intraoperative details, and surgeon experience (Figure 1).

Effective phacoemulsification time (EPT) was defined as the total time of phacoemulsification (seconds) multiplied by mean power of phacoemulsification (percentage). The ARC phaco system (ARC Laser GmbH) was used for phacoemulsification.

The data analysis was performed using SPSS software (version 18.0, SPSS, Inc.). The clinical characteristics of patients with and without vitreous loss were compared in a univariate analysis using the Pearson chi-square or Fisher exact test for categorical variables and the Student *t* test for continuous parameters. The 95% confidence interval (CI) for odds ratio (OR) were calculated. The factors that were statistically significant at a univariate level were then entered into a stepwise multiple logistic regression model. A *P* value less than 0.05 was considered statistically significant.

RESULTS

Overall, 500 eyes of 500 patients, including 255 (51.0%) men and 245 (49.0%) women with a mean age of 67 years ± 10 (SD) (range 27 to 105), were evaluated. Fifty-one eyes (10.2%) developed vitreous loss, and 48 eyes (9.6%) developed posterior capsule rupture and vitreous loss. These complications occurred during phacoemulsification (34 [70.8%]), capsulorhexis (5 [10.5%]), irrigation/aspiration (4 [8.3%]), intraocular lens (IOL) insertion (4 [8.3%]), or hydrodissection (1 [2.1%]). Among complicated eyes, posterior chamber IOL implantation was feasible in 37 eyes (72.5%), while 8 eyes (15.7%) required anterior chamber IOLs because of poor capsule support; 6 eyes (11.8%) remained aphakic.

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Demographic data	Corneal scar
Age	Miotic pupil (<5.0 mm)
Sex	Zonular dehiscence
Laterality (OD vs. OS)	Axial length
Underlying systemic conditions	Anterior chamber depth
Weight	**Surgeon experience**
Smoking	Grade of residency
Hypertension	Total number of cataract surgeries
Diabetes mellitus	Supervision
Ischemic heart disease	**Intraoperative details**
Consumption of anticoagulants	Type of anesthesia
Underlying ocular conditions	Capsulorhexis diameter
Type and grade of cataract	Anterior capsule tear
Preoperative IOP	Surgery technique
Glaucoma	Effective phaco time
Pseudoexfoliation	Floppy-iris syndrome

Figure 1. Patients' characteristics reviewed.

Table 1 shows the association between vitreous complications and clinical characteristics. Table 2 shows the ORs for clinical characteristics associated with vitreous complications in univariate logistic regression analysis. In brief, statistically significant associations were found between vitreous loss and diabetes mellitus (OR, 3.03; $P=.001$), shallow anterior chamber (OR, 0.36; $P=.009$), absence of supervision by a faculty member (OR, 1.83; $P=.04$), larger capsulorhexis (OR, 1.85; $P=.02$), anterior capsule tear (OR, 2.55; $P=.005$), and longer EPT (OR, 1.01; $P=.005$).

Multivariate data analysis using stepwise logistic regression analysis of the aforementioned variables showed anterior capsule tear (OR, 2.63; $P=.03$), longer EPT (OR, 1.01; $P=.02$), and lack of supervision by attending physicians (OR, 4.28; $P=.009$) to be significant independent factors associated with vitreous loss (Table 3).

DISCUSSION

The rate of vitreous loss in our study was 10.2%, which is relatively high. Our findings indicate that supervision by faculty members is an important factor that could decrease the rate of vitreous complications in resident-performed cataract surgery. Although seemingly intuitive, unsupervised surgery leads to worse outcomes and the relatively high rate of vitreous loss among our residents can be partly accounted for by the large percentage of unsupervised surgeries. Obviously, the greater experience and broader knowledge of attending physicians can aid in avoiding complications by their suggesting solutions to residents, such as how to rescue an extending radial tear in capsulorhexis.[5,6] Moreover, preoperative factors (eg, diabetes and shallow anterior chamber) as well as intraoperative events (eg, larger capsulorhexis, anterior

Table 1. Association between vitreous complications and clinical characteristics.

Variable	Complicated (n = 51)	Uncomplicated (n = 449)	*P* Value
Mean age (y) ± SD	70 ± 10	67 ± 11	.053
Male sex, n (%)	27 (54)	228 (51)	.4
Right eye, n (%)	27 (54)	225 (50)	.7
Mean weight (kg) ± SD	66 ± 10	67 ± 12	.4
Smoker, n (%)	14 (28)	60 (13)	.7
Hypertension, n (%)	19 (37)	148 (32)	.6
Diabetes mellitus	16 (31)	35 (8)	.001
IHD	10 (20)	77 (18)	.6
Anticoagulant use	4 (8)	42 (10)	.8
Type of cataract, n (%)			.4
Nuclear sclerosis	35 (69)	302 (67)	
Posterior subcapsular	10 (20)	103 (23)	
Cortical	0	9 (2)	
Mature	6 (11)	35 (8)	
Mean IOP (mm Hg) ± SD	15 ± 2	15 ± 3	.6
Glaucoma, n (%)	6 (11)	72 (16)	.6
Pseudoexfoliation, n (%)	10 (20)	108 (24)	.5
Corneal scar, n (%)	0	18 (4)	.2
Pupil diameter ≤5.0 mm, n (%)	2 (4)	53 (11)	.1
Zonular dehiscence, n (%)	5 (10)	20 (5)	.1
Mean AL (mm) ± SD	23 ± 1	23 ± 2	.8
Mean ACD (mm) ± SD	3.2 ± 0.3	3.4 ± 0.4	.01
Resident grade, n (%)			.055
2	22 (43)	139 (31)	
3	29 (57)	260 (58)	
4	0	50 (11)	
Mean previous operations (n) ± SD	111 ± 78	134 ± 85	.068
Supervision, n (%)			.007
Attending	6 (12)	148 (33)	
Fellow	18 (36)	130 (29)	
Unsupervised	27 (52)	171 (38)	
Anesthesia (%)			.6
Topical	11 (20)	118 (26)	
Local injection	35 (69)	276 (62)	
General	5 (11)	55 (12)	
Mean capsulorhexis size (mm) ± SD	5.2 ± 0.6	5.0 ± 0.5	.02
Anterior capsule tear, n (%)	15 (30)	42 (10)	.001
Phaco technique			.6
Divide and conquer	26 (51)	240 (53)	
Horizontal chop	14 (27)	137 (31)	
Vertical chop	3 (6)	12 (3)	
Other	8 (16)	60 (13)	
Mean EPT (s) ± SD	47 ± 31	34 ± 27	
Floppy-iris syndrome, n (%)	1 (2)	6 (1.3)	.4

ACD = anterior chamber depth; AL = axial length; IHD = ischemic heart disease; IOP = intraocular pressure

capsule tear, and longer EPT) influence the vitreous loss rate.

Studies report a wide range of incidence of vitreous complications in phacoemulsification performed by ophthalmology residents. There is also discrepancy regarding which variables were statistically significant risk factors for vitreous loss. This can be partially explained by differences in study design, inclusion and exclusion criteria, sample size, the power of the study, educational protocols for instructing residents, and criteria for case selection for each level of resident training.

At our hospital, second-year ophthalmology residents begin learning cataract surgery by the phacoemulsification method, while at other centers ECCE is taught first. Case selection for second-year residents

Table 2. Univariate analysis of association between vitreous complications and clinical characteristics.

Variable	Regression Coefficient	OR	95% CI
Age	0.027	1.03	1.00, 1.055
Female vs male	−0.108	0.89	0.50, 1.61
Right eye vs left eye	0.104	1.11	0.62, 1.98
Weight	−0.011	0.99	0.96, 1.01
Smoking vs no smoking	0.513	1.67	0.58, 4.82
Hypertension vs no hypertension	0.172	1.18	0.65, 2.17
Diabetes vs no diabetes	1.108	3.03	1.57, 5.82
IHD vs no IHD	0.168	1.18	0.57, 2.47
Anticoagulant vs none	−0.248	0.78	0.27, 2.27
Nuclear sclerosis cataract vs posterior subcapsular cataract	−0.105	0.90	0.43, 1.87
Nuclear sclerosis cataract vs mature cataract	0.498	1.65	0.65, 4.15
IOP	0.021	1.02	0.93, 1.12
Glaucoma vs none	−0.003	0.99	0.74, 1.34
Pseudoexfoliation vs none	−0.328	0.72	0.35, 1.48
Miotic pupil vs none	−1.206	0.29	0.07, 1.27
Zonular dehiscence vs none	0.794	2.21	0.79, 6.17
Axial length	−0.156	0.86	0.69, 1.05
Anterior chamber depth	−1.033	0.36	0.16, 0.78
Resident grade 2 vs 3 or 4	0.431	1.54	0.85, 2.78
Number of previous operations	−0.003	0.997	0.993, 1.001
Fellow vs attending supervision	0.292	1.34	0.73, 2.46
Unsupervised vs attending supervision	0.604	1.83	1.02, 3.27
Topical vs general anesthesia	−0.327	0.72	0.36, 1.45
Local vs general anesthesia	0.304	1.35	0.72, 2.55
Capsulorhexis size	0.612	1.85	1.11, 3.08
Anterior capsule tear vs none	0.937	2.55	1.32, 4.93
Phaco technique horizontal chop vs divide and conquer	−0.138	0.87	0.46, 1.66
Other phaco techniques vs divide and conquer	−0.06	0.94	0.53, 1.68
Effective phaco time	0.014	1.01	1.004, 1.02
Floppy-iris syndrome vs none	0.385	1.47	0.17, 12.46

CI = confidence interval; IHD = ischemic heart disease; IOP = intraocular pressure; OR = odds ratio

Table 3. Significant risk factors for vitreous loss based on multivariate logistic regression.

Variable	Regression Coefficient	OR	95% CI	*P* Value
Diabetes mellitus	0.683	1.98	0.88, 4.45	.09
Anterior chamber depth	−0.884	0.43	0.17, 1.08	.07
Capsulorhexis size	0.188	1.21	0.61, 2.38	.59
Anterior capsule tear	0.967	2.63	1.09, 6.29	.03
Effective phaco time	0.013	1.01	1.003, 1.02	.02
Unsupervised vs attending supervision	1.629	5.09	1.66, 15.69	.005
Fellow vs attending supervision	1.212	3.36	1.03, 10.93	.044
No attending supervision vs attending supervision	1.453	4.28	1.44, 12.67	.009

CI = confidence interval; OR = odds ratio

is meticulously supervised by faculty members to avoid challenging cases, such as patients with corneal opacities, miotic pupils, pseudoexfoliation (PXF) syndrome, dense and mature cataract, zonulysis, and diabetic retinopathy. In addition, patients who are known to be at high risk for general anesthesia and would rather have surgery under local or topical anesthesia are usually excluded for beginning residents.

In a retrospective study, Blomquist et al.[7] found that older age, poor preoperative visual acuity, left eye, history of trauma, previous PPV, dementia, phacodonesis, zonule dehiscence, posterior polar cataract, white/mature cataract, dense nuclear sclerotic cataract, and poor red reflex were significant risk factors. We excluded patients with traumatic cataract or a history of PPV. In our study, patients with vitreous loss had a higher mean age, although the difference failed to reach statistical significance ($P=.053$). Zonule dehiscence was also 2 times more commonly observed in the complicated group; however, again statistical significance was not found ($P=.1$), which could be because our sample was smaller than in the study by Blomquist et al.,[7] which included 2434 cases. Moreover, the vitreous loss rate in that study was 3.8%, which is significantly lower than our study.

Several studies[8–12] have established that surgeon experience is the most important preoperative factor in cataract surgeries and that the rate of vitreous complications according to surgeon experience varies from 2.0% to 14.7%. In this study, the rate of vitreous loss was 13.6% among second-year residents, 10% among third-year residents, and 0% in the hands of fourth-year residents. However, we found no statistically significant difference in the risk for vitreous loss between the different grades of residents, which may be partly explained by the case selection strategy for beginning residents at our hospital. Tarbet et al.[11] report a vitreous complication rate of approximately 5.3% among second-year residents and 1.3% among third-year residents. These findings clearly indicate that the patients operated on by more experienced surgeons have fewer vitreous complications.

In a study in Iran, Zare et al.[8] found an overall vitreous loss rate of 7.9%, which was 5 times more probable in the hands of residents than in the hands of fellows. However, in contrast to our results, in their study, older age, female sex, small pupil, small capsulorhexis, presence of PXF, and high myopia were significantly associated with vitreous loss. Furthermore, the highest rate of vitreous loss occurred in patients with dense nuclear cataract.[8] Kim et al.[13] found vitreous loss to be more probable in right-handed residents and older patients with small pupils. However, Küchle et al.[14] found an increased risk for vitreous loss in patients younger than 41 years. Abbasoğlu et al.[15] report a 1.7-fold increase in the rate of vitreous loss in patients with systemic hypertension, while we found no significant relationship between hypertension and vitreous complications.

Clever and balanced use of risk stratification systems will allow more appropriate selection of cases for trainee phacoemulsification surgeons to reduce the incidence of vitreous loss in patients with known risk factors. Risk stratification systems that allow prediction of intraoperative complications from preoperative criteria have been devised by Najjar and Awwad,[16] Muhtaseb et al.,[17] and Habib et al.[18] Application of these systems can assist supervising faculty in reserving lower risk cases for the trainees with the least surgical experience so that beginning residents can avoid higher risk cases. Under such a system, residents would continue to be monitored by attending physicians and as their skills and the level of confidence increase with time, they could perform more challenging cases. Structured curricula for resident training and assessment tools for evaluation of residents' surgical competence (eg, Objective Assessment of Skills in Intraocular Surgery[19] and the Global Rating Assessment of Skills in Intraocular Surgery[20]) have been implemented with good results in several residency training programs and can be used in our settings as well.

Our study was performed at a single center and is limited by its small sample, which might have precluded us from finding statistically significant differences for some characteristics that are well-known risk factors for vitreous loss according to larger studies. Larger multicenter studies are suggested to more accurately determine risk factors for vitreous complications in resident-performed cataract surgery in our settings.

In conclusion, we found a relatively high rate of vitreous complications in patients operated on by ophthalmology residents. Risk evaluation before cataract surgery is extremely important, and patients with established risk factors for vitreous loss should be operated on by more experienced surgeons.

WHAT WAS KNOWN

- Posterior capsule rupture and vitreous loss are potentially sight-threatening complications of phacoemulsification. The risk for such complications is markedly higher for less experienced surgeons, including residents.
- Several retrospective studies have determined various preoperative conditions that are associated with an increased risk for vitreous complications.

WHAT THIS PAPER ADDS

- Supervision by faculty physicians played an important role in reducing vitreous complications in phacoemulsification performed by residents.
- Intraoperative factors, including anterior capsule tear and a longer EPT, were significant risk factors for vitreous complications.

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