Title
Efficacy of Preoperative Risk Stratification on Resident Phacoemulsification Surgeries

Authors
Moussa, Omar
Frank, Tahvi
Valenzuela, Ives A
et al.

Publication Date
2022

DOI
10.2147/opth.s368633

Peer reviewed

Clinical Ophthalmology

Dovepress
open access to scientific and medical research

Open Access Full Text Article

ORIGINAL RESEARCH

Efficacy of Preoperative Risk Stratification on Resident Phacoemulsification Surgeries

Omar Moussa[1], Tahvi Frank[2], Ives A Valenzuela[1], Joah Aliancy[1], Dan Gong[3], Joaquin O De Rojas[4], Lora R Dagi Glass[1], Bryan J Winn[5], George A Cioffi[1], Royce WS Chen[1]

[1]Department of Ophthalmology, Edward S. Harkness Eye Institute, Columbia University Irving Medical Center, New York, NY, USA; [2]Columbia University Vagelos College of Physicians and Surgeons, New York, NY, USA; [3]Department of Ophthalmology, Retina Service, Massachusetts Eye and Ear Infirmary, Harvard Medical School, Boston, MA, USA; [4]Center for Sight, Sarasota, FL, USA; [5]Department of Ophthalmology, University of California San Francisco, San Francisco, CA, USA

Correspondence: Royce WS Chen, Department of Ophthalmology, Edward S. Harkness Eye Institute, Columbia University Irving Medical Center, 635 W. 165th St, New York, NY, 10032, USA, Tel +1 212-305-9535, Email rc2631@cumc.columbia.edu

Purpose: To evaluate efficacy of a novel risk stratification system in minimizing resident surgical complications and to evaluate whether the system could be used to safely introduce cataract surgery to earlier levels of training.

Materials and Methods: This is a retrospective cross-sectional study on 530 non-consecutive cataract cases performed by residents at Columbia University. Risk scores, preoperative best corrected visual acuity (BCVA), intraoperative complications, postoperative day 1 (POD1), and month 1 (POM1) exam findings were tabulated. The relationship between risk scores and POD1 and POM1 BCVA was modeled using linear regression. The relationship between risk scores and complication rates was modeled using logistic regression. Logistic regression was used to model the rates of complications across different levels of training. Rates of complications were compared between diabetic versus non-diabetic patients using t-tests.

Results: Risk scores did not have significant association with intraoperative complications. Risk scores were predictive of corneal edema (OR = 1.36, p = 0.0032) and having any POM1 complication (OR = 1.20, p = 0.034). Risk scores were predictive of POD1 (β = 0.13, p < 0.0001) and POM1 (β = 0.057, p = 0.00048) visual acuity. There was no significant association between level of training and rates of intraoperative (p = 0.9) or postoperative complications (p = 0.06). Rates of intraoperative complication trended higher among diabetic patients but was not statistically significant (p = 0.2).

Conclusion: Higher risk scores were predictive of prolonged corneal edema but not risk of intraoperative complications. Our risk stratification system allowed us to safely introduce earlier phacoemulsification surgery.

Keywords: cataract, cataract risk stratification, resident phacoemulsification surgery

Introduction

Age-related cataract is the leading cause of blindness worldwide.[1] It is a well-known major public health problem and has a direct impact on economic and social life. Cataract extraction is a common surgical procedure, in both developed and developing countries.[2,3] With the dramatic rise in volume of cataract surgery performed over the last decade, acquiring optimal visual acuity and reducing risk of complications has become increasingly important. According to annual reports from the American College of Graduate Medical Education, the average number of primary resident phacoemulsification cases in the United States in 2009 was 140 cases. By 2019, this number had grown to an average of 205 cases.[4] With such a rise in resident-performed surgeries over the last decade, and with an emphasis on earlier introduction to primary cases, a natural question arises: are complication rates higher in the hands of less-experienced surgeons?

An objective preoperative risk stratification system aimed at improving surgical outcomes and minimizing complications has been the subject of interest across all surgical specialties.[5,6] After reviewing and identifying the most frequently reported patient risk factors associated with intraoperative complications, Muhtaseb et al proposed a preoperative risk stratification system for phacoemulsification cataract surgery.[7] This system was validated in subsequent independent

Received: 8 April 2022
Accepted: 20 June 2022
Published: 1 July 2022

studies.[8–10] While this risk stratification system was used to assess complication rates for consultants and registrars (the equivalent to a fellow in US training programs), the Buckinghamshire and Butler[11] system was used to evaluate both consultants and trainees. The above studies all applied the concept of cumulative risk from individual risk factors.

We set out to create our own cataract risk stratification system with two goals in mind: 1. To be able to safely introduce cataract surgery for earlier years of training, specifically PGY3-level residents, and 2. To evaluate whether a modified risk stratification system, tailored to our particular educational environment, would be effective in minimizing complication risk for resident cases in a US training program.

Materials and Methods

This is a retrospective cross-sectional study on cataract surgical cases performed by residents at Columbia University Irving Medical Center (CUIMC)/Edward S. Harkness Eye Institute. Data were collected on non-consecutive cases carried out between January 2017 and May 2020. The study protocol was approved by the Institutional Review Board of Columbia University retrospectively and adheres to the tenets set forth in the Declaration of Helsinki and the Health Insurance Portability and Accountability Act. Informed consent was not obtained as the study was performed retrospectively and was qualified for a waiver of informed consent by Columbia University Institutional Review Board.

The risk score (Table 1) utilized in this study was comprised of key risk factors for intraoperative and postoperative complications. The factors and their corresponding point values were selected based on previous risk stratification systems as well as our own faculty expert opinions. Preoperative clinical notes were systematically reviewed, and a risk score was calculated for each case. Risk scores were used to stratify cases among residents at different levels of training. Preoperative best-corrected visual acuity (BCVA) was tabulated from preoperative clinical notes. Clinical notes from routine postoperative day 1 (POD1) and postoperative month 1 (POM1) visits were reviewed, and data were collected on intraoperative complications (posterior capsular rupture, vitreous loss, dropped fragments requiring pars plana vitrectomy, and retinal detachment), postoperative complications (corneal edema present at POM1, pseudophacodonesis, anterior uveitis present at POM1, and macular edema), postoperative BCVA, and surgeon level of training.

Table 1 Preoperative Risk Factors and Their Corresponding Point of Value in Our Risk Stratification System

Risk Category	Score
1. Previous pars plana vitrectomy	1
2. Corneal opacity	1
3. Small pupil (<3mm)	1
4. Shallow anterior chamber depth (<2.5mm)	1
5. Age >88 years	1
6. High ametropia (>6D of myopia or hyperopia)	1
7. Posterior capsule plaque/posterior subcapsular cataract	1
8. Posterior polar cataract	1
9. Guttae	1
10. Post-LASIK	1
11. Alpha blockers	1
12. Dense/brunescent cataract	3
13. Pseudoexfoliation syndrome	3
14. Phacodonesis	3

At the inception of our study, diabetic status was not featured as a risk score in our system; however, we felt that lens disassembly was often more challenging for our residents in diabetic patients. Therefore, we separately studied our surgical results in diabetic patients vs non-diabetic patients to examine if the presence of diabetes could warrant a risk score in our system.

Risk Stratification by Year of Training

We instituted a policy in which starting PGY3 surgeons were only assigned patients with a risk score of 0–1, while more experienced PGY4 surgeons could operate on any risk score.

Descriptive statistics were calculated to assess the rates of different types of complications and BCVA outcomes reported as LogMAR. The relationship between preoperative risk scores and POD1/POM1 LogMAR BCVA was modeled using linear regression in order to evaluate whether risk score was an effective predictor of visual outcome. The relationship between preoperative risk scores and rates of each type of complication were modeled using logistic regression. Rates of complications were compared between diabetic versus non-diabetic patients using t-tests.

Logistic regression was used to model the association between surgeon level of training and rate of each type of complication. Odds ratios were calculated before and after adjusting for the difficulty of cases carried out across the different trainee levels using risk scores.

Results

Data were collected on 530 cataract cases for patients ranging in age from 19 to 90 years, with a mean age of 71 years. Risk scores ranged from 0 to 8, with a mean of 1.31. Most eyes had a risk score of 1 or less, with 179 eyes (33.8%) having a risk score of 1 and 176 eyes (33.2%) having a risk score of 0 (Figure 1).

The most common preoperative risk factor was posterior subcapsular cataract, noted in 158 cases, followed by high ametropia in 112 cases and small pupils in 73 cases.

Intraoperatively, 4.7% of cases had a posterior capsular rupture, 3.8% had vitreous loss requiring anterior vitrectomy, and 1.5% of cases had dropped fragments requiring pars-plana vitrectomy. Retinal detachment did not occur in any cases. At POM1, 5.8% of cases had corneal edema and 1.3% of cases had macular edema. Mean POM1 visual acuity was 0.37 LogMAR, and 80% of cases had visual acuity equal to or better than 0.20 at POM1. Average POM1 visual acuity for cases that had posterior capsular rupture was 0.56 LogMAR (Figure 2).

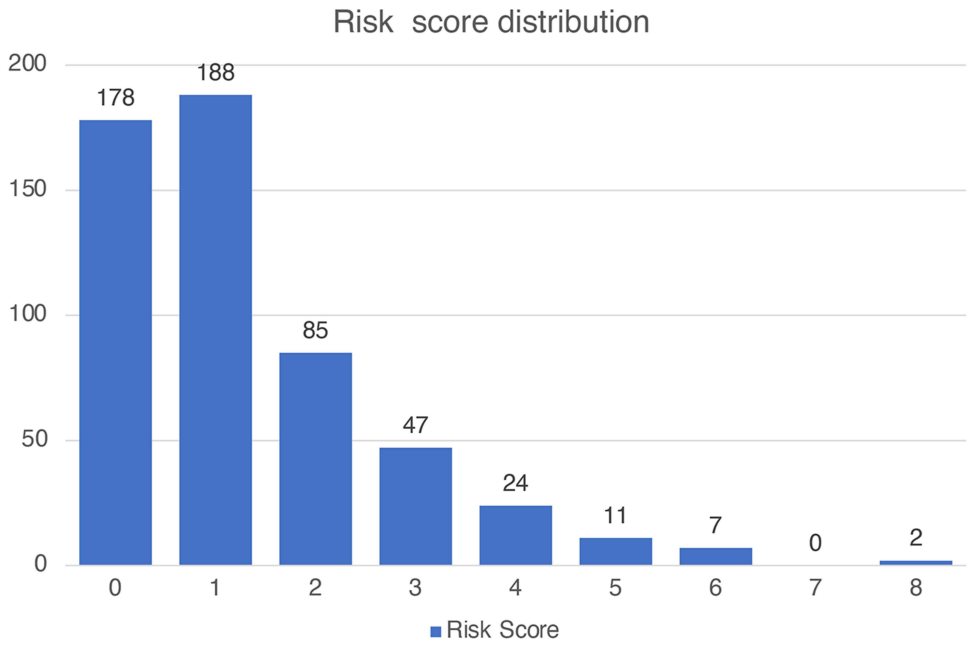

Figure 1 Risk score distribution. Of 530 patients, the majority had a risk score of 0 or 1.

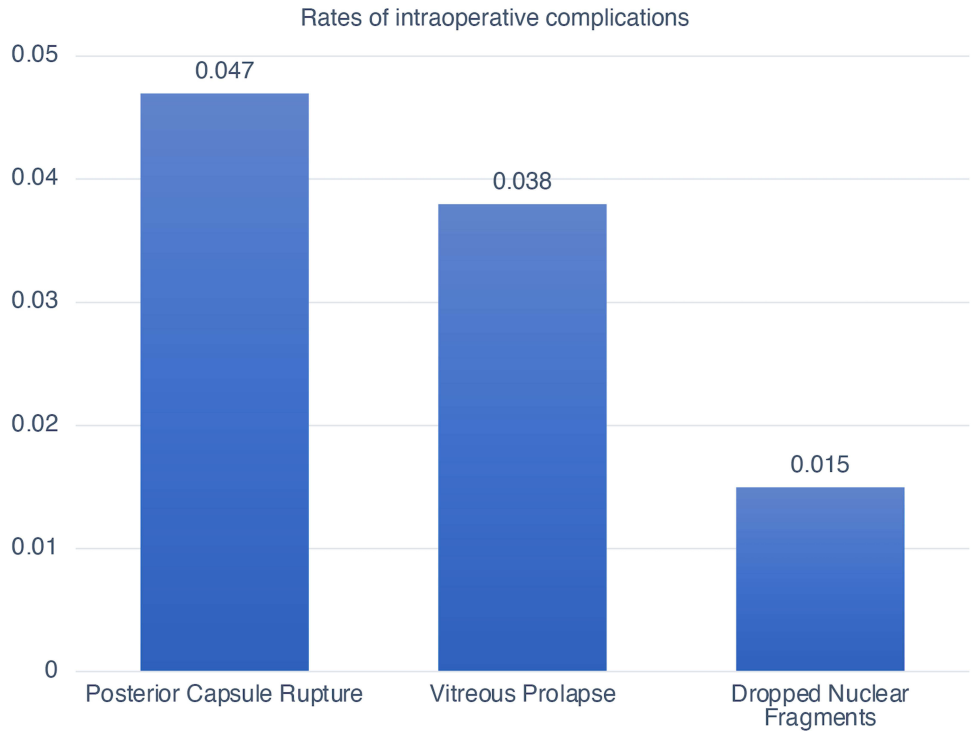

Figure 2 Rates of intraoperative complications. Of 530 cases, 4.7% experienced posterior capsular rupture, 3.8% had vitreous prolapse, and 1.5% developed dropped nuclear fragments requiring pars plana vitrectomy.

Risk scores did not have a significant association with posterior capsule rupture, vitreous loss, or having an intraoperative complication overall. The odds of corneal edema at POM1 increased significantly with increasing risk scores (OR = 1.36, 95% CI 1.11–1.68, p = 0.0032). Risk score was also predictive of having any POM1 complication (corneal edema, macular edema, uveitis, or pseudophacocodonesis), OR = 1.20, 95% CI 1.02–1.34, p = 0.034, and having any complication overall (OR = 1.21, 95% CI 1.05–1.34, p = 0.014). There was a significant association between risk scores and POD1 (β=0.13, SE = 0.023, p < 0.0001) and POM1 (β=0.057, SE = 0.016, p = 0.00048) visual acuity.

Effect of Diabetic Status on Complications

Of the 530 cases undergoing cataract surgery, 245 had diabetes (46.2%). Initially, diabetic status was not included in the data collection as it was not part of our preoperative risk scoring system; however, during the study, our surgeons observed that diabetic cases may contribute to a higher rate of complications due to more challenging nucleus disassembly. We therefore collected and compared rates of complications in diabetic versus non-diabetic patients and found that rates of each type of intraoperative complication trended higher among patients with diabetes: 5.7% of diabetic patients had a posterior capsular rupture compared to 3.9% of non-diabetic patients (OR = 1.51, 95% CI 0.67–3.39, p = 0.3), 5.3% of diabetic patients had vitreous loss versus 2.5% of non-diabetic patients (OR = 2.2, 95% CI 0.87–5.67, p = 0.09), and 2.4% of diabetic patients had dropped fragments versus 0.7% of non-diabetic patients (OR = 3.5, 95% CI 0.71–17.76, p = 0.12) (Figure 3). Although the incidence of each intraoperative complication appeared higher in diabetic patients, none of these comparisons reached statistical significance, likely due to small sample sizes and an overall low rate of complications in both groups.

Rates of Intraoperative and Postoperative Complications Stratified by Year of Training

Four hundred and eighty-four cases were performed by surgeons in PGY4, and 46 cases were performed by surgeons in PGY3. The mean risk score of cases performed by surgeons in PGY4 was 1.36, versus 0.86 for cases done by surgeons in PGY3. There were 81/484 cases with at least one complication in PGY4 and only 3/46 cases with at least one

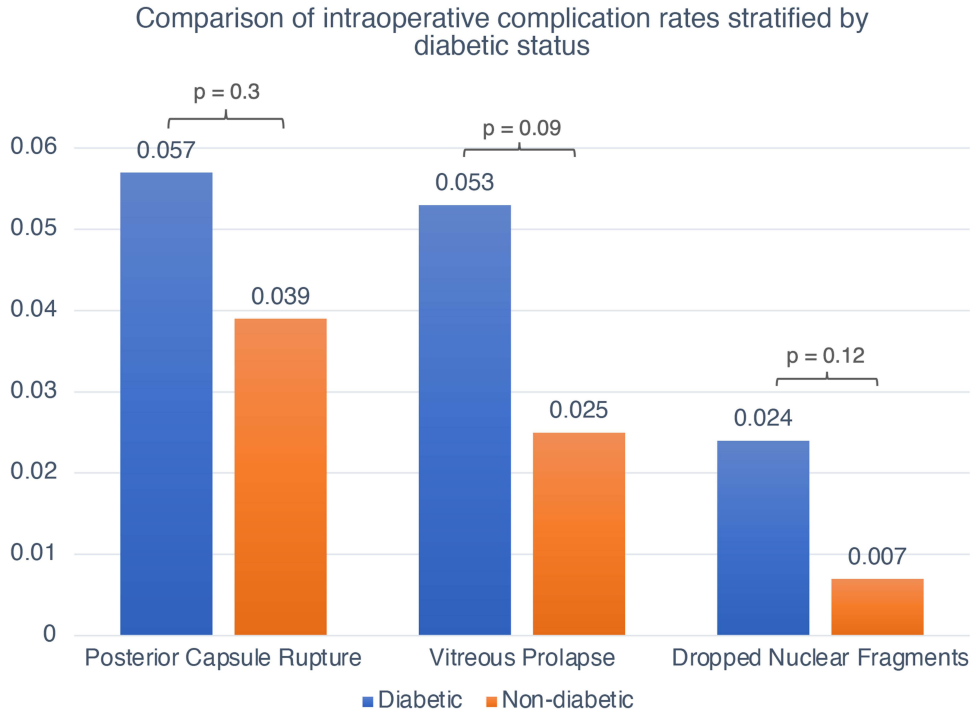

Figure 3 Intraoperative complication rates stratified by diabetic status. 245/530 (46.2%) eyes were in patients with diabetes. Of these, there was a trend toward higher intraoperative complication rates compared to patients without diabetes; however, differences did not reach statistical significance.

complication in PGY3. The rate of intraoperative complications was 4.9% for surgeons in PGY4 compared to 4.6% for surgeons in PGY3 (OR = 1.07, 95% CI 0.24–4.68, p = 0.9, before adjusting for risk score). The rate of postoperative complications was 13.2% in PGY4 and 2.3% in PGY3 (OR = 6.4, 95% CI 0.86–47.3, p = 0.06, before adjusting for risk score). After adjusting for risk score, the risk of intraoperative complications for PGY4 vs PGY3 was OR = 1.1, 95% CI 0.25–4.87, p = 0.8, and the postoperative complication risk for PGY4 vs PGY3 were OR = 5.7, 95% CI 0.77–42.6, p = 0.08 (Figure 4).

Discussion

Our study demonstrates that risk scores did not have a significant association with intraoperative complications. However, higher risk score was significantly associated with higher odds of postoperative complications, especially POM1 corneal edema. This can be explained by more complex cases with higher risk scores requiring the utilization of more phacoemulsification energy and longer surgical times. The Auckland study[12] validated both the Muhtaseb and the Buckinghamshire preoperative risk scoring systems. They concluded that risk of intraoperative complications increases with higher risk scores using both systems. Additionally, the Buckinghamshire risk score correlated with postoperative complications.

While diabetic status was not initially included in our risk score, we observed that our trainees experienced more challenges with diabetic patient cataract extraction, which might lead to higher rates of complications. We therefore studied diabetes as an independent risk factor for complication. Rates of intraoperative complications trended higher in patients with diabetes, but the differences did not reach statistical significance. A recent multicenter study on 179,159 eyes found higher rates of posterior capsule rupture and dropped nuclear fragments in diabetic patients undergoing phacoemulsification surgery compared to non-diabetics.[13] Rate of posterior capsule rupture was 2.1% in the diabetic group compared to 1.6% in non-diabetics. 0.3% of diabetic patients had dropped nuclear fragments, compared to 0.2% of non-diabetics.[13] Diabetes (with or without retinopathy) was found to be a risk factor for posterior capsule rupture with an OR of 1.263. It was proposed that diabetes may increase the rate of posterior capsule rupture owing to increased surgical complexity from poor pupillary dilation, denser cataract, or prior vitrectomy.[13] While the Buckinghamshire system included diabetic retinopathy as one of the preoperative risk factors, neither they nor the Muhtaseb system had diabetic

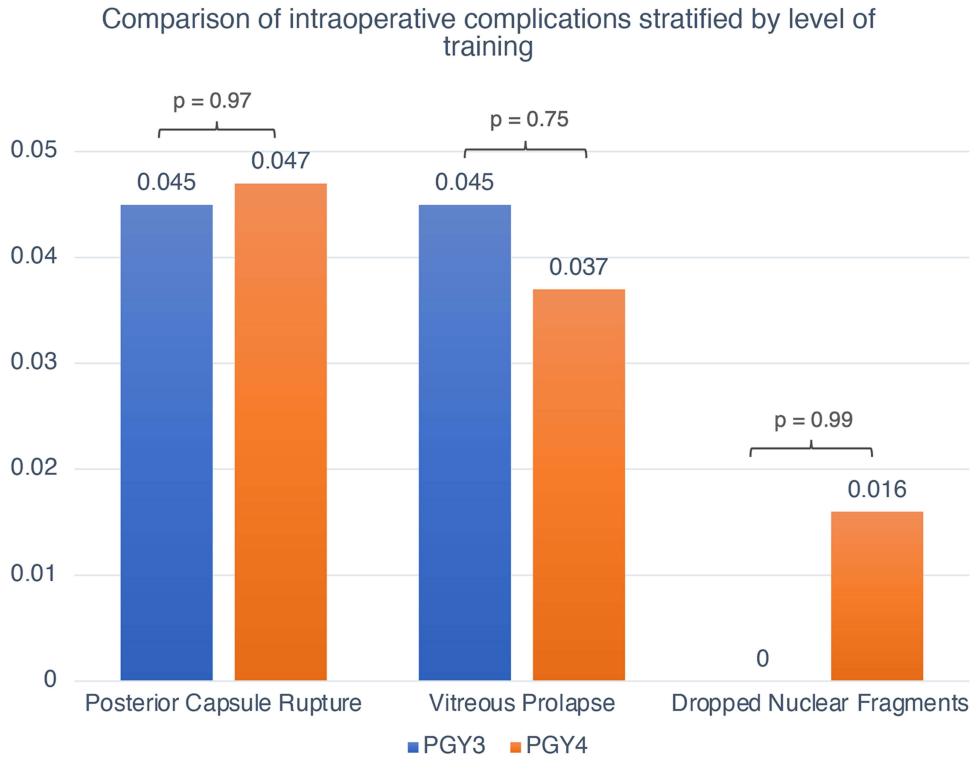

Figure 4 Intraoperative complications stratified by level of training. There was not a significant association between level of training and rates of intraoperative complications.

status as a preoperative risk factor. A future analysis comparing the relationship of HbA1c and rates of intra and postoperative complications would be interesting.

Surgeries in this study were performed by residents in their PGY3 and PGY4 year of training. No significant relationship was found between level of training and rates of intraoperative or postoperative complications, both before and after adjusting for case mix. This suggests that our risk stratification system was successful when used to stratify cases among residents with different levels of training and demonstrates that an earlier introduction to primary intraocular surgery does not result in worse patient outcomes. In the Auckland study,[12] residents and fellows did not have significantly higher or lower complication rates in comparison to attending physicians before and after case-mix adjustment using the preoperative Muhtaseb score.

Of note, all cases were staffed with a group of 9 seasoned attending cataract surgeons. Although intraoperative times may have been prolonged due to more challenges in nucleus disassembly or cortical removal, it is likely that our attending surgeons were able to recognize when a complication was about to occur, and therefore were able to prevent complications that may have otherwise been associated with higher preoperative risk scores. It is also possible that a higher number of cases analyzed would have revealed a correlation between risk score and intraoperative or postoperative complication, but given the lack of a trend towards significance, we believe that the former explanation is more likely.

Our study was performed on 530 non-consecutive cases operated on over a 3-year period at CUIMC, as the risk score stratification sheet was not recovered for every case performed by the residents. A total of 1922 cataract cases were performed by 18 residents at CUIMC over the same time period. For the sake of uniformity, these cases did not include several hundred more cases performed at our other major teaching site, Harlem Hospital Center, but we expect the results and complication rates to be similar at this site, as the core attendings are the same in both locations. Overall, we found the following rates of intraoperative complications over the 1922 cases: 3.7% posterior capsule rupture, 2.6% vitreous prolapse requiring anterior vitrectomy, and 1.5% dropped nuclear fragments requiring pars plana vitrectomy.

At POM1, 80% of our cases had visual acuity equal to or better than 20/30. Of note, patients with history of diabetic retinopathy, glaucoma, or other retinal pathologies were not excluded from this study.

Given that our complication rates for the risk stratification cases (n = 530) were higher than the rate of complications for the overall pool (n = 1922), we feel confident that the stratification scores did not underestimate the overall rate of complications in our study cohort.

We reviewed previous studies examining complication rates in resident-performed phacoemulsification surgery. Rutar et al at the University of California, San Francisco, found an intraoperative complication rate of 4.7%, which included 3.1% of patients with vitreous loss.[14] Rogers et al at the University of Iowa studied the impact of a structured surgical curriculum on resident phacoemulsification intraoperative complication rates and found that implementation of the curriculum reduced the rate of posterior capsular tears from 7.17% to 3.77%.[15] Our rates of posterior capsular rupture of 4.7% in the risk stratification cohort (n = 530) and 3.7% in the overall cohort (n = 1922) compare favorably with these two studies.

Limitations of this study include a small sample size and lack of consecutive cases. Additionally, intraoperative time, intraoperative phacoemulsification energy used, hemoglobin A1c, and level of intervention by attending physicians were not measured.

Conclusion

We report on a novel method for preoperative risk stratification of cataract surgeries and demonstrate its efficacy for minimizing intra- and postoperative complications across PGY3 and PGY 4 levels at a single US residency training program. Risk scores were found to be predictive of POD1 and POM1 BCVA, as well as POM1 complications, specifically prolonged corneal edema.

Our scoring system found no significant relationship between level of training and rates of intraoperative and postoperative complications. This suggests that using this system to stratify cases of different complexity among residents with different levels of training is effective and can be used for earlier introduction of cataract surgery in training programs without increasing risk of complications.

Diabetic status was not included in our preoperative risk score classification. However, diabetic patients appeared to have higher rates of both intraoperative and postoperative complications. Differences between diabetic and non-diabetic outcomes did not reach statistical significance, likely because of relatively small study numbers and an overall low rate of complications. Nonetheless, based on the trends in our study, as well as results from the recent multicenter study, we will be adding diabetic status to our risk stratification system in the future.[13]

As educators, we all strive to achieve the fine balance between optimal patient care and outstanding surgical training for novice physicians. We feel that this cataract risk stratification system may be a useful tool to achieve both goals.

Acknowledgments

The abstract of this paper was presented at the Association of Research in Vision and Ophthalmology as a conference talk with interim findings. The abstract was published in "Poster Abstracts" in the Investigative Ophthalmology and Visual science Journal: https://iovs.arvojournals.org/article.aspx?articleid=2773835.

Funding

OM, TF, IAV, JA, DG, JOD, LRDG, BJW, GAC, and RWSC were supported by National Eye Institute Core Grant P30EY019007 and an unrestricted grant from Research to Prevent Blindness. The funding organization had no role in the design or conduct of this research.

Disclosure

RWSC is a consultant for Carl Zeiss Meditec, Inc. Dr Lora R Dagi Glass reports royalties for Ophthalmology Q&A Board Review Book from Thieme Publishers, outside the submitted work. The authors report no other conflicts of interest in this work.

References

1. Khairallah M, Kahloun R, Bourne R, et al. Number of people blind or visually impaired by cataract worldwide and in world regions, 1990 to 2010. *Invest Ophthalmol Vis Sci*. 2015;56(11):6762–6769. doi:10.1167/iovs.15-17201

2. Murthy G, John N, Shamanna BR, Pant HB. Elimination of avoidable blindness due to cataract: where do we prioritize and how should we monitor this decade? *Indian J Ophthalmol*. 2012;60(5):438–445. doi:10.4103/0301-4738.100545
3. Tabin G, Chen M, Espandar L. Cataract surgery for the developing world. *Curr Opin Ophthalmol*. 2008;19(1):55–59. doi:10.1097/ICU.0b013e3282f154bd
4. American college of graduate medical education annual reports. Available from: https://apps.acgme.org/ads/Program/CaselogReport/CaselogReportDownload?reportId=106493. Accessed September 5, 2021.
5. Liu C. Risk stratification for the humble cataract. *Br J Ophthalmol*. 2004;88(10):1231–1232. doi:10.1136/bjo.2004.048207
6. Bilimoria KY, Liu Y, Paruch JL, et al. Development and evaluation of the universal ACS NSQIP surgical risk calculator: a decision aid and informed consent tool for patients and surgeons. *J Am Coll Surg*. 2013;217(5):833–42.e423. doi:10.1016/j.jamcollsurg.2013.07.385
7. Muhtaseb M, Kalhoro A, Ionides A. A system for preoperative stratification of cataract patients according to risk of intraoperative complications: a prospective analysis of 1441 cases. *Br J Ophthalmol*. 2004;88(10):1242–1246. doi:10.1136/bjo.2004.046003
8. Osborne SA, Adams WE, Bunce CV, Fraser SG. Validation of two scoring systems for the prediction of posterior capsule rupture during phacoemulsification surgery. *Br J Ophthalmol*. 2006;90(3):333–336. doi:10.1136/bjo.2005.080754
9. Tsinopoulos IT, Lamprogiannis LP, Tsaousis KT, et al. Surgical outcomes in phacoemulsification after application of a risk stratification system. *Clin Ophthalmol*. 2013;7:895–899. doi:10.2147/OPTH.S42726
10. Agrawal V, Upadhyay J, Cataract I, Indian Cataract Risk Stratification Study group. Validation of scoring system for preoperative stratification of intra-operative risks of complications during cataract surgery: Indian multi-centric study. *Indian J Ophthalmol*. 2009;57(3):213–215. doi:10.4103/0301-4738.49396
11. Butler TK. Risk stratification and assessment in cataract surgery. *J Cataract Refract Surg*. 2012;38(1):184. doi:10.1016/j.jcrs.2011.10.022
12. Kim BZ, Patel DV, Sherwin T, McGhee CN. The Auckland Cataract Study: assessing Preoperative Risk Stratification Systems for Phacoemulsification Surgery in a Teaching Hospital. *Am J Ophthalmol*. 2016;171:145–150. doi:10.1016/j.ajo.2016.09.003
13. Chancellor J, Soliman MK, Shoults CC, et al. Intraoperative complications and visual outcomes of cataract surgery in diabetes mellitus: a multicenter database study. *Am J Ophthalmol*. 2021;225:47–56. doi:10.1016/j.ajo.2020.12.027
14. Rutar T, Porco TC, Naseri A. Risk factors for intraoperative complications in resident-performed phacoemulsification surgery. *Ophthalmology*. 2009;116(3):431–436. doi:10.1016/j.ophtha.2008.10.028
15. Rogers GM, Oetting TA, Lee AG, et al. Impact of a structured surgical curriculum on ophthalmic resident cataract surgery complication rates. *J Cataract Refract Surg*. 2009;35(11):1956–1960. doi:10.1016/j.jcrs.2009.05.046