• Clinical Research •

Incidence and risk factors for vitreous loss in residents performing manual small-incision cataract surgery

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Abstract

● **AIM:** To assess the incidence of vitreous loss and associated risk factors in residents performing manual small-incision cataract surgery (MSICS).

● **METHODS:** The present retrospective record review study was performed on 490 patients who underwent MSICS performed between November 2018 and December 2019 by 7 third-year postgraduate residents. The study group comprised of patients having intraoperative vitreous prolapse. All the surgeries were performed under supervision of a trained assistant.

● **RESULTS:** The mean age of the participants at the time of surgery was 68.42±2.05y. Of the 490 patients, 250 patients were male, and 240 patients were female (*P*=0.23). A total of 215 (43.9%) eyes had mature white cataract, 185 (37.8%) eyes had brown cataract, and 90 (18.3%) eyes had immature senile cataract. The incidence of intraoperative vitreous loss among residents was 2% (10/490). Vitreous loss occurred during hydrodissection [1/10 (10%)], nucleus delivery [3/10 (30%)], irrigation and aspiration [5/10 (50%)], and intraocular lens insertion [1/10 (10%)]. Multivariate stepwise Logistic regression analysis confirmed immature senile cataract [odds ratio (OR)=3.99; *P*=0.02], irrigation and aspiration of cortical material (OR=3.07; *P*=0.03), and anterior capsular extension (OR=3.22, *P*=0.03) as independent risk factors for vitreous loss.

● **CONCLUSION:** Immature senile cataract, irrigation and aspiration of cortical material, and anterior capsular extension are independent risk factors for vitreous loss. Our findings may serve as a guide for future trainers or residents learning MSICS.

● **KEYWORDS:** manual small-incision cataract surgery; complications of cataract surgery; vitreous loss

INTRODUCTION

Cataract surgery is the most commonly performed eye surgery in the world[1]. Despite significant development in the technique of cataract surgery, the burden of blindness due to cataract continues to increase in developing countries[2-3]. Thus, competent ophthalmologists capable of performing cataract surgery without any complications are highly required. Most of the cataracts in the Asian population are hard cataracts because patients generally present late for surgery[4-6]. Manual small-incision cataract surgery (MSICS) is the preferred technique for cataract removal in developing countries[7-8]. The MSICS technique involves the creation of a self-sealing sclerocorneal tunnel, removal of nucleus through the tunnel, and placement of an intraocular lens (IOL) inside the capsular bag. The technique is popular in developing countries because of less investment required and its low cost, less dependency on machine, rapidity, and excellent outcomes with a low complication rate[9-10]. MSICS can be performed in hard, brown, and black cataractous lenses. Phacoemulsification cataract surgery in such cataracts may cause high ultrasonic power consumption with effect on the corneal endothelium. Manipulation of such hard cataracts may lead to zonular weakness. The residency program in developing countries focuses on providing training in extracapsular cataract extraction and MSICS, whereas the residency program in developed countries focuses on phacoemulsification as the preferred method for cataract surgery[11-13].

Vitreous loss is a serious complication of cataract surgery that is responsible for the suboptimal visual outcome after cataract surgery[14-16]. It may lead to retinal detachment, glaucoma, cystoid macular edema, persistent corneal edema, and IOL displacement. A study conducted in Aravind Eye Hospital, Madurai, compared the intraoperative complication

rate between phacoemulsification, MSICS, and large-incision extracapsular cataract extraction performed by trainee surgeons and reported that the complication rate with phacoemulsification is significantly higher than with MSICS[7]. Gupta *et al*[17] reported a vitreous loss rate of 1.85% in MSICS performed by residents who were learning MSICS. Haripriya *et al*[7] reported vitreous loss rates of 0.87% and 0.64% in phacoemulsification and MSICS, respectively. Lynds *et al*[18] also reported a vitreous loss rate of 1.9% in a small series of MSICS. Haripriya *et al*[7] studied the intraoperative complication rates of phacoemulsification, MSICS, and large-incision extracapsular cataract extraction performed by staff surgeons well trained in all types of cataract surgeries, fellowship students in their postresidency training, visiting trainees who were practicing ophthalmologists, and residents enrolled for the postgraduation program. However, to the best of our knowledge, none of the studies have focused on determining the incidence of vitreous prolapse and correlative factors associated with vitreous loss in the central Indian population in a tertiary eye care center.

SUBJECTS AND METHODS

Ethical Approval The study was approved by the Institutional Ethics Committee and was performed in accordance with the Declaration of Helsinki. Written informed consent was obtained from the subject and none of the participants received any finances.

The present retrospective record review study was performed in 490 patients undergoing cataract surgeries through the MSICS technique from November 2018 to December 2019 by 7 third-year residents (JR3) at a tertiary eye care center, which is providing free cataract services in central India. Patients assigned to the residents during the course of their residency were considered and was not a continuous allotment. The study population included patients visiting to the hospital for consultation and admitted to the hospital for cataract surgery. Data on age; sex; history of trauma, diabetes mellitus, hypertension, and cardiac problems; corrected distance visual acuity; intraocular pressure; anterior chamber (AC) depth (derived from optical biometry); slit-lamp examination after pupillary dilatation for evidence of pseudoexfoliation and subluxation of cataract; and grade of cataract were collected. Retinal examination was performed using indirect ophthalmoscopy.

Patients with only one functional eye, pseudoexfoliation, subluxated cataract, post-vitrectomized eye, posterior polar cataract, primary open or closed angle glaucoma, traumatic cataract, and all types of complicated cataract were excluded from the study.

Surgical Procedure All MSICSs were performed under peribulbar anesthesia and under the supervision of a senior surgeon. All the surgeries were performed from the superior side. The procedure started with conjunctival peritomy and clearing of the Tenon's layer. Light wet-field cautery was applied to the bleeding vessels. A scleral groove of 8-9 mm length was performed with a No.15 blade approximately 1-1.5 mm behind the limbus. A sclerocorneal tunnel was constructed with the help of a crescent blade. Dissection was performed 2 mm inside the cornea. A paracentesis was created on the temporal side and on the nasal side for surgery on the right and left eye, respectively. The size of the side port was approximately 2.4 mm. The anterior capsule was stained with trypan blue dye under air in all the cases. The AC was filled with ophthalmic viscosurgical device (OVD). The continuous curvilinear capsulorhexis (CCC) was performed using utrata forceps or a 26-g bent needle cystitome. The diameter of the CCC was kept between 5.5 and 6.5 mm. The final size of CCC was measured with the help of Castroviejo caliper. AC was entered with the 3.2-mm keratome through the sclerocorneal tunnel created superiorly. The size of the sclerocorneal tunnel was enlarged to 7-8 mm with the help of a crescent blade. Hydrodissection was performed, and the nucleus was prolapsed out of the capsular bag with a dialer. If the nucleus was large and failed to prolapse, the CCC was enlarged after initiating a small cut at the margin with the help of Vanna's scissor and extension was performed using capsulorhexis forceps. After the nucleus was brought out in the AC, OVD was injected posterior to the nucleus to push back the posterior capsule. Viscoexpression of the nucleus was performed using a wire vectis. The AC was formed with the OVD. Simcoe's cannula was introduced through the side port (2.4 mm) for the cortical clean-up. The capsular bag was filled with OVD, and a single-piece polymethyl methacrylate IOL was implanted in the capsular bag. Anterior vitrectomy was performed in case of posterior capsular rent (PCR) with vitreous loss, and the IOL was placed over the anterior capsular rim by the supervising surgeon. The sclerocorneal tunnel was secured and sutured with a 10-0 nylon suture if any wound leak was noted. The side port incision was hydrated. The supervising surgeon monitored the phase in which the PCR occurred, the vitreous loss, placement of IOL, and complications.

Statistical Analysis Data were entered in an MS Excel sheet, and statistical analysis was performed using SPSS version 13.0 (SPSS Inc, Chicago, IL, USA). The data are expressed as mean±standard deviation (SD) or number and percentage. Fisher's exact test was used for categorical variables, whereas the Student's *t*-test was used for continuous variables. The confidence interval (CI) for calculation of the odds ratio (OR) was 95%. Univariate and multivariate Logistic regressions were performed for the factors responsible for vitreous loss, and a *P* value of <0.05 was considered statistically significant.

RESULTS

The mean age of the participants at the time of surgery was 68.42±2.05y, with a range of 62-78y. Of the 490 patients, 250 patients were male and 240 patients were female (P=0.23). Of the total surgeries performed, 205 (41.8%) surgeries were performed on the right eye and 285 (58.1%) surgeries were performed on the left eye. Among the cases allotted to the residents, 215 (43.9%) cases exhibited mature white cataract, 185 (37.8%) cases exhibited brown cataract, and 90 (18.3%) cases exhibited immature senile cataract. Each resident included in the study had performed an average of 68 surgeries (range 45-80).

The incidence of intraoperative vitreous loss was 2% (10/490), and 5 eyes (1%) developed PCR without vitreous loss. Vitreous loss occurred during hydrodissection [1/10 (10%)], nucleus delivery [3/10 (30%)], irrigation and aspiration [5/10 (50%)], and IOL insertion [1/10 (10%)]. Patient who had vitreous loss during hydrodissection and nucleus drop required nucleus removal, pars plana vitrectomy, and scleral fixation of IOL. In patients having vitreous loss during irrigation and aspiration of the cortical matter, anterior vitrectomy was performed and placement of IOL over the rim of anterior capsule was done. None of the patient remained aphakic. Patients having zonular dehiscence were fixed with endocapsular ring and an anterior vitrectomy was done and IOL was placed in the capsular bag.

Table 1 illustrates the association between the clinical characteristics and vitreous loss. Systemic factors, such as diabetes mellitus and hypertension, and ocular factors, such as AC depth and size of the capsulorhexis, did not exhibit any correlation with the vitreous loss. On univariate Logistic regression analysis (Table 2), a statistically significant association of vitreous loss with immature cataract (OR=2.99; P=0.04), irrigation and aspiration (OR=3.07; P=0.02), and anterior capsular extension (OR=3.02; P=0.04) was observed.

Multivariate stepwise Logistic regression analysis (Table 3) also confirmed immature senile cataract (OR=3.99; P=0.02), irrigation and aspiration of cortical material (OR=3.07; P=0.03), and anterior capsular extension (OR=3.22, P=0.03) as independent risk factors for vitreous loss.

Table 1 Association between clinical characteristics and vitreous loss

Variable	Patient with vitreous loss (n=10)	Patient without vitreous loss (n=480)	P
Age	67±2	68±3	0.13
Sex (male/female)	6/4	244/236	0.11
Right/left eye	5/5	200/280	0.15
Hypertension	1	104	0.11
Diabetes mellitus	1	110	0.14
Blood thinner use	-	78	0.20
Type of cataract			-
Mature white cataract	2	213	
Brown cataract	2	183	-
Immature cataract	6	84	-
Capsulorhexis size (mm)	6±0.2	6±0.3	0.12
Anterior chamber depth (mm)	2.78±0.2	2.79±0.3	0.10
Anterior capsular extension	5	1	0.05
Hydrodissection	1	-	-
Nucleus delivery	3	-	-
Irrigation and aspiration	5	-	-
IOL implantation	1	-	-

The data are expressed as mean±standard deviation or number and percentage. Fisher's exact test was used for categorical variables, whereas the Student's t-test was used for continuous variables.

Table 2 Univariate analysis of clinical characteristics associated with vitreous loss

Variable	Odds ratio	95% confidence interval
Age	0.99	0.65, 0.57
Sex (male/female)	0.012	0.23, 0.99
Right/left eye	0.76	0.66, 0.95
Hypertension	0.46	0.67, 1.02
Diabetes mellitus	0.89	0.76, 0.98
Blood thinner use	-0.22	0.54, 0.99
Type of cataract		
Mature white cataract	0.67	1.22, 0.67
Brown cataract	0.99	0.78, 0.76
Immature cataract	2.99	2.53, 4.78
Capsulorhexis size (mm)	0.56	0.88, 1.02
Anterior chamber depth (mm)	0.76	1.02, 0.55
Anterior capsular extension	3.02	0.77, 1.05
Hydrodissection	0.33	0.56, 0.32
Nucleus delivery	0.37	1.02, 0.89
Irrigation and aspiration	3.07	2.01, 4.67
IOL implantation	0.21	0.15, 0.67

IOL: Intraocular lens.

DISCUSSION

Vitreous loss is the major intraoperative complication of cataract surgery. The present study indicated a vitreous loss rate of 2% in MSICS. This rate is higher than that reported in a study by Haripriya *et al*[7], who reported a vitreous loss rate of 0.64% in MSICS when they compared the complication rates between phacoemulsification and MSICS; this difference may be because staff and trainee surgeons were included as participants in the study, whereas the present study included only JR3 students. Lynds *et al*[18] reported the incidence rate of vitreous loss of 1.9% in a supervised residents training at a large urban United States residency training program. Gupta *et al*[17] exhibited a posterior capsular rupture with a vitreous loss rate of 1.76% in their study on the learning curve for MSICS in a tertiary eye care center in residents entering second postgraduate residency.

Table 3 Multivariate regression analysis of significant clinical characteristics associated with vitreous loss

Variable	Odds ratio	95% confidence interval	*P*
Mature cataract *vs* immature cataract	3.99	3.53, 5.78	0.02
Capsulorhexis size (mm)	1.56	1.00, 1.52	0.12
Anterior chamber depth (mm)	1.22	1.12, 0.78	0.22
Anterior capsular extension	3.22	0.98, 1.15	0.03
Hydrodissection	0.43	0.52, 0.33	0.66
Nucleus delivery	0.37	1.02, 0.89	0.22
Irrigation and aspiration of cortical material	3.07	2.23, 4.90	0.03
IOL implantation	0.22	0.19, 0.70	0.11

Univariate and multivariate Logistic regressions were performed for the factors responsible for vitreous loss, and a *P* value of <0.05 was considered statistically significant.

In the present study five eyes (1%) exhibited PCR; however, no vitreous loss was observed. The IOL was safely placed in the capsular bag. The vitreous loss after PCR can be avoided by plugging the rent with high molecular weight OVD. This helps to maintain the AC and prevent the extension of PCR. The rate of PCR in MSICS reported in various studies varies from 0.14% to 1.9%[7,9,19]. This finding is in contrast to those of studies, which have reported the rate of vitreous loss ranging from 3.8% to 5.1% and on the higher side in surgeries performed by residents learning phacoemulsification[7,20-22]. This could be due to steeper learning curve for phacoemulsification. Subudhi *et al*[23] have shown steep learning curve for residents performing MSICS.

Reasons for inconsistencies in the reported vitreous loss rates in various studies on MSICS could be due to differences in the surgical technique, exclusion criteria, training program schedules in the institutes, and supervised or unsupervised training. Designing of a surgical schedule may ensure uniformity in postgraduate training in surgical procedures[24-25]. PCR identification is crucial to prevent further postoperative complications occurring due to vitreous loss. The number of cataract surgeries performed by the residents influences the rate of intraoperative complications. Gupta *et al*[17] observed that surgeries performed by residents having performed an average of 100 surgeries are thrice more likely to exhibit intraoperative complications than those performed by residents who have already performed 600 surgeries.

To the best of our knowledge, none of the studies on MSICS have focused on the most vital complication of cataract surgery, namely vitreous loss. The present study was conducted in residents having performed an average of 68 MSICS; therefore, more complications were expected. However, each case was supervised by a senior surgeon, who intervened in case of any complication. Supervised MSICS learning has shown vitreous loss in one case out of 52 patients stressing the significance of supervision[18]. Hashemi *et al*[19] reported a vitreous loss rate of 10.2% in unsupervised cataract surgery by residents. Supervision assists not only in avoiding intraoperative complications but also in case selection[26]. Patients with a shallow AC, subluxation, uncooperative attitude, small pupil, traumatic cataract, post-vitrectomized eyes, glaucoma, and pseudoexfoliation were excluded from the study.

Gupta *et al*[17] observed that older patients exhibit higher intraoperative complications than younger patients. Similar observation were made by Hashemi *et al*[19] and Blomquist *et al*[27]. However, no such preponderance was reported in our study.

Gupta *et al*[17] noted that intraoperative complications are more in left-eye operated MSICS patients than in those with right eye surgery; the reason stated was that the nasal bridge of the patients hinders free movement of right-handed surgeons. This finding is in contrast with the findings of our study, where vitreous loss was observed equally in the right and left eye (n=5, P=0.15), and none of the surgeons in our study were left-handed.

The present study identified preoperative factors, such as immature senile cataract (OR=3.99; P=0.02), and intraoperative factors, such as irrigation and aspiration of cortical material (OR=3.07; P=0.03) and anterior capsular extension (OR=3.22, P=0.03), as independent risk factors for vitreous loss on multivariate analysis. Studies on phacoemulsification have reported that mature and hard nuclear cataract are associated with vitreous loss in surgeries performed by residents[27-28]. Additionally, Gupta *et al*[17] exhibited that intraoperative complications are more in eyes having mature and hard cataract; however, due to lack of preoperative data on the cataract morphology, they used preoperative visual acuity as an indicator for the hardness and maturity of cataract. In the present study, 6 eyes with immature cataract and 2 eyes each with mature white, and brown cataract exhibited vitreous loss. Prolapsing the nucleus out of the capsular bag is difficult in immature cataract with small capsulorhexis. Damage to the zonular fibers may occur with repeated attempts to prolapse nucleus into the AC. Cases having zonular dehiscence,

capsular bag was fixed with a capsular tension ring and an anterior vitrectomy was performed. Haripriya *et al*[7] also noted the vitreous loss rate of 1.85% with zonular dehiscence in MSICS. Gupta *et al*[17] noted a vitreous loss rate of 0.37% with zonular dehiscence. Furthermore, removal of cortical matter from the equatorial area becomes challenging if pupil becomes small. Moreover, a tendency of blind aspiration of cortical fibers is present in a small pupil. Conversely, no or little cortex is required to be cleared from the AC in a mature cataract. Cortical removal must be performed carefully.

Extended anterior capsulorhexis is another crucial factor influencing vitreous loss (OR=3.22, P=0.03). Hashemi *et al*[19] also identified anterior capsular tear as an independent factor for vitreous loss in surgeries performed by residents learning phacoemulsification. In MSICS, shallow AC may occur during nucleus expression. Therefore, the likelihood of extension of the anterior capsular tear toward the posterior capsule is high. AC formation with OVD does help to prevent extension of anterior capsular tear to the posterior capsule.

Hydrodissection (n=1) and IOL implantation (n=1) are another vital step associated with vitreous loss. Patient who exhibited vitreous loss after hydrodissection had mature cataract. This patient required pars plana vitrectomy, nucleus removal, and scleral fixated IOL.

At our institute, training for MSICS starts at the end of first year of JR1. Procedures that are taught initially include the construction of a scleral tunnel, creation of a side port, staining of the anterior capsule with trypan blue dye, CCC, and hydrodissection in a stepwise and supervised manner. The stepwise learning helps in reducing complications. Additionally, students are trained in performing phacoemulsification. Simulator based learning has been shown to reduce complications while performing cataract surgery[29-30].

The present study has certain limitations. The study was performed at a single center in a retrospective manner with limited number of participants who were in their third year of residency. Although the data were collected from electronic medical records, multiple surgeons were involved in the supervision of the residents. Being a nonrandomized study, the study is prone to case selection bias; however, guidelines regarding the type of cataract to be allotted to the residents in training was difficult to formulate. Residents require strict supervision while performing certain steps of MSICS such as capsulorhexis, nucleus delivery, and cortical aspiration.

Thus, a vitreous loss rate of 2% was observed in our study. On multivariate analysis, preoperative factor, namely immature senile cataract, and intraoperative factors, namely irrigation and aspiration of cortical material and anterior capsular extension, were identified as independent risk factors for vitreous loss. These findings may serve as a guide for future trainers or residents learning MSICS.

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