Visual and Anatomical Outcomes of Pars Plana Vitrectomy for Dropped Nucleus after Phacoemulsification

Ali Lashgari¹, MD; Majid Kabiri¹, MD; Alireza Ramezani²³, MD; Morteza Entezari¹, MD; Saeed Karimi¹³, MD; Sajad Kakaei¹, MD; Mehdi Yaseri¹⁴, PhD; Homayoun Nikkhah¹³, MD

¹Ophthalmic Research Center, Shahid Beheshti University of Medical Sciences, Tehran, Iran
²Ophthalmic Epidemiology Research Center, Shahid Beheshti University of Medical Sciences, Tehran, Iran
³Department of Ophthalmology, Torfeh Hospital, Shahid Beheshti University of Medical Sciences, Tehran, Iran
⁴Department of Epidemiology and Biostatistics, School of Public Health, Tehran University of Medical Sciences, Tehran, Iran

Abstract

Purpose: To determine the prognostic factors and visual and anatomic outcomes of pars plana vitrectomy (PPV) in patients with dropped nucleus following complicated phacoemulsification (PE).

Methods: The records of patients with complicated PE who underwent PPV to remove posteriorly dislocated nucleus fragments from January 2011 to December 2014 were retrospectively reviewed.

Results: Of 43 patients, 36 patients (36 eyes) were included with mean age of 73 ± 9.5 years and mean follow-up duration of 23.8 ± 15.3 (range 4–53) months. The mean interval between cataract surgery and PPV was 11.5 ± 9.6 (range 1–45) days. The pre-PPV mean best-corrected visual acuity (VA) was 1.04 ± 0.24 logMAR, which improved to 0.46 ± 0.18 logMAR (P < 0.001). Pre-PPV VA ≥20/200 was significantly associated with good final VA ≥20/40 (P = 0.002). Implantation of intraocular lens (IOL) at the time of complicated PE and complicated course after PPV were significantly associated with poor visual outcome of <20/40 (P = 0.041 and P < 0.001, respectively). However, the timing of PPV, route of nucleus removal, and final IOL status were not significantly associated with the visual outcome. The most frequent causes of poor visual outcome were optic atrophy, cystoid and/or diabetic macular edema, history of rhegmatogenous retinal detachment, and pre-existing eye disease (age-related macular degeneration).

Conclusion: PPV for dropped nucleus was associated with improved VA. Better pre-PPV VA was associated with good visual outcome, while inserting IOL at the time of complicated PE, and complicated course after PPV were associated with poor visual outcome.

Keywords: Dropped Nucleus; Phacoemulsification; Pars Plana Vitrectomy; Visual Outcome

J Ophthalmic Vis Res 2018; 13 (3): 253-259

INTRODUCTION

Phacoemulsification is currently the most common surgical technique used for cataract extraction. Loss of nucleus or
Outcomes of PPV for Dropped Nucleus after Phacoemulsification; Lashgari et al

...nucleus into the vitreous cavity is one of the most serious complications of phacoemulsification and may occur during any stage of surgery.[1] This complication can result in sight-threatening outcomes because of elevated intraocular pressure (IOP), corneal edema, uveitis, rhegmatogenous retinal detachment (RRD), and other sequelae.[2-4] Nucleus fragment drop usually happens when phacoemulsification is performed by inexperienced surgeons, but may also occur when performed by experienced operators. The reported incidence rate ranges between 0.3% and 1.1%.1,5

Pars plana vitrectomy (PPV) and release of vitreous adhesions from the dropped nucleus, followed by removal of the dislocated lens fragments using a phacofragmatome or vitrectomy probe is the most effective solution.[6]

The final visual outcome after PPV for dropped nucleus has been reported to be ≥20/40 in 44%-71.3% of patients.[7-10] The aims of this study were to evaluate the visual and anatomic outcomes of PPV for dropped nucleus and if possible to determine the prognostic factors affecting the final visual outcome.

METHODS

The study protocol was approved by the Institutional Review Board and Ethics Committee of Shahid Beheshti University of Medical Sciences. The medical records of all patients who were referred after complicated phacoemulsification and underwent PPV for dropped nucleus from January 2011 to December 2014 at our two tertiary referral hospitals (Imam Hossein Medical Center and Torfeh Medical Center) were retrospectively reviewed. Patients were included if they had complete data and at least 3 months of follow-up. Patients with traumatic cataract, traumatic lens subluxation, or advanced proliferative diabetic retinopathy were excluded.

The patients’ demographics and pre-PPV parameters, including age, sex, best-corrected visual acuity (BCVA), IOP, presence of corneal edema, inflammation of the anterior chamber, and anterior uveitis (anterior chamber reaction of 3+ cells or more), gauge of the instruments used, size of the dropped nucleus, presence of RRD, and the interval between complicated cataract surgery and PPV were recorded.

All patients underwent standard 20-gauge or 23-gauge 3-port PPV with complete release of the vitreous strands surrounding the retained lens material. The dropped nucleus was removed from the vitreous cavity using a vitrectomy probe or phacofragmatome. Use of perfluorocarbon liquid during surgery and tamponade at the end of the procedure were according to the surgeon’s preference. Intraoperative and postoperative complications, including vitreous hemorrhage, formation of retinal breaks, and retinal detachment were recorded.

Each surgical procedure was performed by one of the three experienced vitreoretinal surgeons (HN, ME, or AR). Betamethasone eye drops every 2-4 hours being tapered over one month, chloramphenicol eye drops every 6 hours for one week, and homatropine eye drops every 8 hours for 2 weeks were administered after surgery.

Post-PPV parameters, including BCVA, IOP, anatomic results, final IOL status, and complications during follow-up were recorded.

BCVA was measured using the Snellen acuity chart and then converted to the logarithm of the minimum angle of resolution (logMAR) for the purposes of statistical analysis. A final BCVA of ≥20/40 was considered a good visual outcome and <20/40 as a poor outcome. The causes of a poor visual outcome were sought.

Data were analyzed using IBM SPSS Statistics for Windows version 21.0 software (released 2012, IBM Corp., Armonk, NY, USA). Normality of the distribution of the quantitative data was checked using a Q-Q plot and the Kolmogorov-Smirnov test. Wilcoxon signed-rank test was used to evaluate the changes in each group. Mann-Whitney test was used to compare the ordinal and quantitative non-normally distributed variables between two groups. Chi-squared and Fisher’s exact tests were used to compare nominal variables between two groups. P values <0.05 were considered statistically significant. Simple and multiple logistic regression models were used to obtain the raw and adjusted associations of the pre-PPV, intraoperative PPV, and post-PPV variables with the final visual outcomes.

RESULTS

Of the 43 patients identified to have undergone surgery for retained lens material, 36 eyes from 36 patients had complete information recorded and were included. The 36 patients (19 men, 17 women) had a mean age of 73.0 ± 9.5 (range 42-91) years. The mean interval between complicated cataract surgery and PPV was 11.4 ± 9.2 (range 1–45) days. Sixteen patients underwent surgery in the first week after cataract surgery (≤7 days) and the others after this time [Table 1].

At presentation, IOP higher than 25 mmHg and retinal breaks with concurrent RRD were present in 6 (16.7%) and 4 eyes (11.1%), respectively. There was shallow macular detachment in all 4 cases of RRD. No patient was on anti-glaucoma medication at the time of presentation. Neither hypopyon nor endophthalmitis was observed in any cases. Poly methyl methacrylate (PMMA) IOL had been implanted in the ciliary sulcus in 11 (30.6%) eyes and the other eyes had been left aphakic. Seven patients (19.4%) had vitreous in the anterior chamber; 4 (57.1%) of them had an IOP >25 mmHg. However, only 2 (6.9%) of 29 eyes that underwent appropriate anterior
Outcomes of PPV for Dropped Nucleus after Phacoemulsification; Lashgari et al

Vitrectomy during complicated phacoemulsification had a high IOP at presentation ($P = 0.008$, odds ratio = 18, 95% confidence interval 2.3–143.3).

Standard 3-port PPV was performed using 20-gauge and 23-gauge probes in 25 (69.4%) and 11 eyes (30.6%), respectively. A 3-piece foldable posterior chamber IOL was implanted in 16 eyes (44.4%) and an artisan aphakia iris claw lens in 9 eyes (25%) [Table 2].

Silicone oil was injected at the end of PPV in 4 patients (11.1%) who had concurrent RRD; a 3-piece IOL was implanted in 2 of these patients, an aphakic artisan iris claw lens was implanted at the time of PPV in 1 patient, and 1 patient was left without an IOL. At the final follow-up visit, the retina was attached and the IOP was <25 mmHg in all 4 patients, 3 of whom (8.3%) were on anti-glaucoma medication. Silicone oil was removed in all 4 cases.

The mean pre-PPV BCVA was 1.04 ± 0.24 (range 0.3–1.3) logMAR which improved to 0.46 ± 0.18 (range 0.1–1.0) logMAR at the final visit ($P < 0.001$). The pre-PPV visual acuity (VA) was <20/40 in 35 eyes (97.2%) and <20/200 in 13 eyes (36.1%). At the final visit, VA improved to ≥20/40 in 12 eyes (33.3%, $P < 0.001$). Only one eye (2.8%) had a final VA <20/200 ($P < 0.001$) [Table 3]. Eight eyes in this series had a pre-existing eye disease (RRD and age-related macular degeneration, 4 eyes each). Excluding the eyes with pre-existing disease, 12 patients (43%) had a final VA ≥20/40, 16 (57%) had a final VA <20/40, and no patient had a VA <20/200.

Univariate regression analysis was performed to identify pre-PPV variables associated with a good visual outcome. A pre-PPV VA ≥20/200 and the patient being left aphakic at the end of cataract surgery were significantly associated with a good final visual outcome ($P = 0.002$ and $P = 0.041$, respectively). The interval between complicated phacoemulsification and PPV had no significant impact on the final visual outcome ($P = 0.246$) [Table 4]. Intraoperative variables, including use of a phacofragmatome or vitrectomy probe to remove the retained lens material and final IOL status were not associated with the visual outcome ($P > 0.05$). However, in the eyes with a complicated course after PPV (e.g. development of epiretinal membrane, cystoid macular edema, or optic atrophy), the likelihood of achieving a final BCVA ≥20/40 was significantly less in the univariate analysis ($P < 0.001$) [Table 5]. We used a backward stepwise selection method to determine the factors associated with a final BCVA ≥20/40 in a multiple logistic regression model that considered preoperative, intraoperative, and post-PPV variables. The only significant variable in the model was the patient being left aphakic (odds ratio 13.2, 95% confidence interval 1.24–140.7, $P = 0.033$).

The primary cause of low vision in the patients with a final VA <20/40 was optic atrophy (7 eyes), epiretinal membrane (3 eyes), cystoid and/or diabetic macular edema at presentation ($P = 0.008$, odds ratio = 18, 95% confidence interval 2.3–143.3).

### Table 1. Baseline patient demographics and clinical characteristics

| Variable                                   | Value  |
|--------------------------------------------|--------|
| Patients ($n$)                             | 36     |
| Age (years) Mean±SD                        | 73±9.5 |
| Median (range)                             | 73.5 (42-91) |
| Sex                                        |        |
| M (%)                                      | 19 (52.8%) |
| F (%)                                      | 17 (47.2%) |
| Follow-up (months)                         |        |
| Mean±SD                                    | 24.2±15.8 |
| Median (range)                             | 18.5 (4-53) |
| Interval between cataract surgery and PPV (days) | 11.4±9.2 |
| Mean (range)                               | 8.5 (1-45) |
| Corneal edema at presentation $n$ (%)      | 15 (41.7%) |
| Postoperative uveitis at presentation $n$ (%) | 20 (55.6%) |
| IOP >25 mmHg at presentation $n$ (%)       | 6 (16.7%) |
| Implantation of IOL at the end of cataract surgery $n$ (%) | 11 (30.6%) |
| Retinal detachment at presentation $n$ (%) | 4 (11.1%) |
| IOL, intraocular lens; IOP, intraocular pressure; PPV, pars plana vitrectomy; SD, standard deviation

### Table 2. Intraoperative and post-pars plana vitrectomy variables

| Variable                                   | $n$ (%) |
|--------------------------------------------|---------|
| Gauge of instrument used for vitrectomy    |         |
| 20                                         | 25 (69.4%) |
| 23                                         | 11 (30.6%) |
| Size of dropped nucleus                    |         |
| ≥1/4 to <1/2                               | 18 (50.0%) |
| ≥1/2 to <3/4                               | 18 (50.0%) |
| Manner of nucleus                          |         |
| Vitrectomy probe                           | 23 (63.9%) |
| Removal                                    |         |
| Phacofragmatome                            | 13 (36.1%) |
| Patients on anti-glaucoma medication at their last visit |         |
| Yes                                        | 3 (8.3%) |
| No                                         | 33 (91.7%) |
| Final IOL status                           |         |
| 3 piece*                                   | 16 (44.4%) |
| Artisan**                                  | 9 (25%)  |
| PMMA                                       | 11 (30.6%) |

*3-piece foldable posterior chamber IOL. **Artisan aphakia iris claw lens. IOL, intraocular lens; PMMA, poly methyl methacrylate; PPV, pars plana vitrectomy
edema (4 eyes), a history of RRD (4 eyes), corneal edema and IOL subluxation (1 eye each), and age-related macular degeneration (4 eyes).

**DISCUSSION**

PPV is the preferred management for dropped nucleus after complicated cataract surgery. In most cases, removal of lens fragments leads to improvement in VA and reduces inflammation and IOP.

The mean BCVA in our patients improved significantly after PPV, which is consistent with previous reports. However, the percentage of eyes that achieved a final VA ≥20/40 was lower than in previous reports. Excluding eyes with pre-existing disease, 43% of eyes in this study had a final VA ≥20/40, which is comparable to other reports (44%–75%). Pre-existing eye disease has been associated with less improvement in VA after PPV as is seen in the current study. Twenty-three eyes (63.9%) in this study achieved a final VA between 20/200 and 20/40, which is better than in previous series (13%–37%). Only 1 patient (2.8%) had a VA <20/200 at the final visit, which is less than the previous reports of 5%–37%. The timing of PPV did not have any significant effect on the final VA outcome, which is again consistent with previous reports. This may reflect selection bias; for example, eyes with severe inflammation, markedly elevated IOP, or larger nuclear fragments are often referred earlier and undergo earlier PPV, whereas eyes with smaller nuclear fragments and controlled IOP are likely to be referred later. Therefore, more severe cases usually receive earlier treatment.

### Table 3. Best corrected log MAR visual acuity at presentation and final visit

| Variable | Pre-PPV | Last visit | Change | P-within† |
|----------|---------|------------|--------|------------|
| BCVA     | Mean±SD | 1.04±0.24  | 0.46±0.18 | −0.58±0.15 | <0.001 |
|          | Median (range) | 1 (0.3-1.3) | 0.45 (0.1-1) | −0.6 (−0.8, −0.2) | <0.001 |
| BCVA     | <20/200 n (%) | 13 (36.1%) | 1 (2.8%) | <0.001 |
|          | ≥20/200 to <20/40 n (%) | 22 (61.1%) | 23 (63.9%) | |
|          | ≥20/40 n (%) | 1 (2.8%) | 12 (33.3%) | |

†Based on Wilcoxon signed-rank test. BCVA: Best-corrected visual acuity; PPV: Pars plana vitrectomy

### Table 4. Pre-pars plana vitrectomy variables associated with good or poor visual outcomes in univariate analysis

| Variable | Total† | Final BCVA‡ | P |
|----------|--------|-------------|---|
|          | <20/40 | ≥20/40      |   |
| Interval between cataract surgery and PPV | | | |
| ≤7       | 16 (44.4%) | 9 (56.3%) | 7 (43.8%) | 0.246* |
| >7       | 20 (55.6%) | 15 (75.0%) | 5 (25.0%) | |
| Pre-PPV BCVA | | | |
| <20/200 | 13 (36.1%) | 13 (100.0%) | 0 (0.0%) | 0.002** |
| ≥20/200 | 23 (63.9%) | 11 (47.8%) | 12 (52.2%) | |
| Dropped nucleus size | | | |
| >1/4 to ≤1/2 | 18 (50.0%) | 14 (77.8%) | 4 (22.2%) | 0.157* |
| >1/2 to ≤3/4 | 18 (50.0%) | 10 (55.6%) | 8 (44.4%) | |
| IOL implantation at the end of cataract surgery | | | |
| No | 25 (69.4%) | 14 (56.0%) | 11 (44.0%) | 0.041* |
| Yes | 11 (30.6%) | 10 (90.9%) | 1 (9.1%) | |
| RRD at presentation | | | |
| Yes | 4 (11.1%) | 4 (100.0%) | 0 (0.0%) | 0.278** |
| No | 32 (88.9%) | 20 (62.5%) | 12 (37.5%) | |
| IOP >25 mmHg at presentation | | | |
| Yes | 6 (16.7%) | 4 (66.7%) | 2 (33.3%) | 1** |
| No | 30 (83.3%) | 20 (66.7%) | 10 (33.3%) | |

†The percentages are presented in all cases. ‡The percentage is presented within each variable stratum. *Based on the Chi-square test. **Based on Fisher’s exact test. BCVA, best-corrected visual acuity; IOL, intraocular lens; IOP, intraocular pressure; PPV, pars plana vitrectomy; RRD, rhegmatogenous retinal detachment
Table 5. Intraoperative and post-pars plana vitrectomy variables associated with good or poor visual outcomes in univariate analysis

| Variable                                      | Total1 | ≤20/40 | ≥20/40 | P         |
|-----------------------------------------------|--------|--------|--------|-----------|
| Manner of nucleus removal                     |        |        |        |           |
| Vitrectomy probe                              | 23 (63.9%) | 15 (65.2%) | 8 (34.8%) | >0.99**   |
| Phacofragmatome                               | 13 (36.1%) | 9 (69.2%) | 4 (30.8%) |           |
| Final IOL status                              |        |        |        |           |
| 3-piece acrylic foldable IOL                  | 16 (44.4%) | 8 (50.0%) | 8 (50.0%) | 0.093**   |
| Artisan aphakia iris claw lens                | 9 (25.0%) | 6 (66.7%) | 3 (33.3%) |           |
| PMMA                                          | 11 (30.6%) | 10 (90.9%) | 1 (9.1%) |           |
| Complicated course                            |        |        |        |           |
| No                                            | 12 (33.3%) | 0 (0.0%) | 12 (100.0%) | <0.001*   |
| Yes                                           | 24 (66.7%) | 24 (100.0%) | 0 (0.0%) |           |

1 The percentages are presented in all cases. 2 The percentage is presented within each variable stratum. *Based on the Chi-square test. **Based on Fisher’s exact test. BCVA, best-corrected visual acuity; IOL, intraocular lens; PMMA, poly methyl methacrylate; PPV, pars plana vitrectomy.

Outcomes of PPV for Dropped Nucleus after Phacoemulsification; Lashgari et al

outcomes. Specifically, 12 eyes (52.2%) with an initial BCVA ≥20/200 had a final VA ≥20/40, while all patients with an initial BCVA <20/200 had a final VA <20/40. Patients with better VA after complicated cataract surgery were more likely to have fewer intraoperative or postoperative complications, including corneal edema, glaucoma, uveitis, and RRD. Therefore, they had a greater likelihood of achieving a better final VA.

In previous studies, using a fragmatome to remove retained lens fragments was associated with a significantly worse visual outcome[10] as well as an increased risk of RRD, albeit not statistically significant.[10,20] In the present study, there was no significant association between use of a phacofragmatome and a poor visual outcome or an increased risk of RRD. This might be explained by the use of better instruments and performing complete vitrectomy before using a fragmatome.

Margherio et al reported significant differences in final visual outcomes according to lens status. Eyes with posterior chamber IOL had better vision than those with anterior chamber IOL, and both groups had better vision than aphakic patients. This finding was attributed to the degree of complications encountered at the time of cataract surgery, for which lens status would be a marker.[7] In our series, the final status of the lens did not have any impact on the visual outcome, as in two previous studies.[16,21] Our patients who were left aphakic at the time of cataract surgery had a significantly better final visual outcome in both univariate and multivariate analyses. Rose et al reported similar findings.[22]

Although Watts et al reported no association between insertion of an IOL at the time of complicated cataract surgery and the final visual outcome, they believed that IOL implantation at the time of phacoemulsification made vitrectomy more difficult and that insertion of the IOL into the ciliary sulcus at the end of corrective vitrectomy was safe.[23] We suggest that less manipulation and the shorter operating time in eyes that were left aphakic during phacoemulsification caused less corneal edema, inflammation, uveitis, and retinal problems such as cystoid macular edema, thus contributing to a better final visual outcome.

In the present study we did not find a significant association between the size of the retained lens fragments and the final visual outcome or ocular complication rates.

In our study, elevated IOP (≥25 mmHg) was detected in 6 eyes (16.7%) at presentation. This complication has been reported in 25%–52% of cases in other series.[16,20,21] We found a statistically significant difference in the prevalence of elevated IOP at presentation between patients who had undergone appropriate anterior vitrectomy and those who had not. A similar association was reported by Ho et al.[25] The residual vitreous in the anterior chamber increases the risk of uveitis and trabeculitis, and therefore, may contribute to IOP elevation.

In this study, retinal breaks and RRD were found in 4 eyes (11.1%) before PPV; however, no new retinal breaks or subsequent RRD were found after PPV. Tajunisah and Reddy reported no RRD after PPV in their patients,[24] while in a large series, Moore et al reported RRD in 19 (5.5%) of 343 patients after PPV for retained lens fragments.[25] Another study identified RRD in 3.1% of patients.[26] Ho et al noticed that the older studies had higher rates of RRD after PPV than the more recent series.[16] This may be related to the use of smaller-gauge PPV and the availability of better equipments in recent years.

We found optic atrophy, cystoid and/or diabetic macular edema, and a history of RRD or age-related macular degeneration to be the most common causes of low vision (BCVA <20/40) after PPV. Previous studies have also cited retinal detachment and macular problems, such as macular edema, macular hole, and...
age-related macular degeneration, as the reasons for decreased VA.\textsuperscript{9,10} Scott et al reported cystoid macular edema as the most common cause of decreased final vision after PPV and advocated aggressive treatment of macular edema in these patients.\textsuperscript{18}

Optic atrophy was detected in 7 eyes in our series. Three of these 7 cases had silicone oil endotamponade for a long period. Silicone oil has been demonstrated to cause degeneration of the optic nerve.\textsuperscript{27} Furthermore, post-PPV optic neuropathy may be caused by mechanical trauma to the optic nerve during induction of posterior vitreous detachment.\textsuperscript{28} Reduced ocular perfusion pressure and systemic hypotension during PPV may be responsible for posterior ischemic optic neuropathy.\textsuperscript{29}

Since PE complicated with nucleus drop is not very common, a small sample size cannot be avoided. This holds true in our study even though it covered a four-year period.

In conclusion, PPV for posteriorly dislocated lens fragments was associated with improved VA in this study. Leaving the eye aphakic at the time of primary cataract surgery and a better pre-PPV VA were significantly associated with better final visual outcomes. A complicated course after PPV reduces the likelihood of obtaining a good VA; therefore, long-term follow-up is recommended. Further prospective trials that include more cases may improve our ability to determine the visual outcome and its predictors after PPV for cataract surgery complicated by dropped nucleus.

Financial Support and Sponsorship
Nil.

Conflicts of Interest
There are no conflicts of interest.

REFERENCES

1. Pande N, Dobbs TR. Incidence of lens matter dislocation during phacoemulsification. J Cataract Refract Surg 1996;22:737-742.
2. Smiddy WE, Guererro JL, Pinto R, Feuer W. Retinal detachment rate after vitrectomy for retained lens material after phacoemulsification. Am J Ophthalmol 2003;135:183-187.
3. Rossetti A, Doro D. Retained intravitreal lens fragments after phacoemulsification: Complications and visual outcome in vitrectomized and non-vitrectomized eyes. J Cataract Refract Surg 2002;28:310-315.
4. Cohen SM, Davis A, Curkwoski C. Cystoid macular edema after pars plana vitrectomy for retained lens fragments. J Cataract Refract Surg 2006;32:1521-1526.
5. Aasuri MK, Kompella VB, Majji AB. Risk factors for and management of dropped nucleus during phacoemulsification. J Cataract Refract Surg 2003;27:1428-1432.
6. Rofagha S, Bhishitkul RB. Management of retained lens fragments in complicated cataract surgery. Curr Opin Ophthalmol 2011;22:137-140.
7. Margherio RR, Margherio AR, Pendergast SD, Williams GA, Garretson BR, Strong LE, et al. Vitrectomy for retained lens fragments after phacoemulsification. Ophthalmology 1997;104:1426-1432.
8. Hanson LJ, Larsson J. Vitrectomy for retained lens fragments in the vitreous after phacoemulsification. J Cataract Refract Surg 2002;28:1007-1011.
9. Salam GA, Greene JM, Deramo VA, Tibrewala RK, Ferrone PJ, Fastenberg DM. Retinal tears and retinal detachment as factors affecting visual outcome after cataract extraction complicated by posteriorly dislocated lens material. Retina 2005;25:570-575.
10. Al-kahtier A, Wong D, Lois N, Cota N, Yang YC, Groenewald C. Determinations of visual outcome after pars plana vitrectomy for posteriorly dislocated lens fragments in phacoemulsification. J Cataract Refract Surg 2001;27:1199-1206.
11. Scapola A, Abed E, Sammarco MG, Grimaldi G, Sasso P, Parrilla R, et al. Gauge Pars Plana Vitrectomy for Retained Lens Fragments in Complicated Cataract Surgery. Ophthalmologica 2015;234:101-108.
12. Baker PS, Spinn MJ, Chiang A, Regillo CD, HO AC, Vander JF, et al. 23-Gauge transconjunctival pars plana vitrectomy for removal of retained lens fragments. Am J Ophthalmol 2011;152:624-627.
13. Von Lany H, Mahmood S, James CR, Cole MD, Charles SJ, Foot B, et al. Displacement of nuclear fragments into the vitreous complicating phacoemulsification surgery in the UK: Clinical features, outcomes and management. Br J Ophthalmol 2008;92:493-495.
14. Ho Ly, Doft BH, Wang L, Bunker CH. Clinical predictors and outcomes of pars plana vitrectomy for retained lens material after cataract extraction. Am J Ophthalmol 2009;147:587-594.
15. Orlin A, Parlitsis G, Chiu YL, D’Amico DJ, Chan RV, Kiss S. A comparison of same setting versus delayed vitrectomy in the management of retained lens fragments after cataract surgery. Retina 2014;34:1969-1976.
16. Ho SF, Zaman A. Clinical features and outcomes of pars plana vitrectomy in patients with retained lens fragments after phacoemulsification. J Cataract Refract Surg 2007;33:2106-2110.
17. Ghasemi Falavarjani K, Hashemi M, Jallili Fazel A, Modarres M, Nazari H, Parvaresh MM. Pars plana vitrectomy and intravitreal phacoemulsification for dropped nuclei. J Ophthalmic Vis Res 2012;7:125-129.
18. Scott IU, Flynn HW Jr, Smiddy WE, Murray TG, Moore JK, Lemus DR, et al. Clinical features and outcomes of pars plana vitrectomy in patients with retained lens fragments. Ophthalmology 2003;110:1567-1572.
19. Vanner EA, Stewart MW, Liesegang TJ, Bendel RE, Bolling JP, Hasan SA. A retrospective cohort study of clinical outcomes for intravitreal crystalline retained lens fragments after age-related cataract surgery: A comparison of same-day versus delayed vitrectomy. Clin Ophthalmol 2012;6:1135-1148.
20. Borne Mj, Tasman W, Regillo C, Malecha M, Sarin L. Outcomes of vitrectomy for retained lens fragments. Ophthalmology 1996;103:971-976.
21. Merani R, Hunyor AP, Playfair TJ, Chang A, Gregory-Roberts J, Hunyor AB, et al. Pars plana vitrectomy for the management of retained lens material after cataract surgery. Am J Ophthalmol 2007;144:364-370.
22. Ross WH. Management of dislocated lens fragments after phacoemulsification surgery. Can J Ophthalmol 1996;31:234-240.
23. Watts P, Hunter J, Bunce C. Vitrectomy and lensectomy in the management of posterior dislocation of lens fragments. J Cataract Refract Surg 2000;26:832-837.
24. Tajunisah I, Reddy SC. Dropped nucleus following phacoemulsification cataract surgery. Med J Malaysia 2000;26:364-367.
25. Moore JK, Scott IU, Flynn HW Jr, Smiddy WE, Murray TG, Kim JE, et al. Retinal detachment in eyes undergoing pars plana vitrectomy for removal of retained lens fragments. Ophthalmology 2003;110:709-714.
26. Olokoba L, Islam T, Nahar N, Mahmoud A, Olokoba A. A 3-year review of the outcome of pars plana vitrectomy for dropped lens fragments after cataract surgery in a tertiary eye hospital in Dhaka, Bangladesh. *Ethiop J Health Sci* 2017;27:427-432.

27. Budde M, Cursiefen C, Holbach LM, Naumann GO. Silicone oil-associated optic nerve degeneration. *Am J Ophthalmol* 2001;131:392-394.

28. Hutton WL, Fuller DG, Snyder WB, Fellman RL, Swanson WH. Visual field defects after macular hole surgery: A new finding. *Ophthalmology* 1996;103:2152-2159.

29. Bansal AS, Hsu J, Garg SJ, Sivalingam A, Vander JF, Moster M, et al. Optic neuropathy after vitrectomy for retinal detachment: Clinical features and analysis of risk factors. *Ophthalmology* 2012;119:2364-2370.