Contemporary Outcomes and Prognostic Factors of 23-Gauge Vitrectomy for Retained Lens Fragments After Phacoemulsification

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• PURPOSE: To provide data on visual acuity (VA) outcomes and prognostic factors of microincision (23-gauge) vitrectomy surgery (MIVS) for retained lens fragments after complicated cataract surgery.

• DESIGN: Retrospective, interventional case series from 2012 to 2017.

• METHODS: Precataract surgery and intraoperative (vitrectomy) parameters, postvitrectomy complications, and best-corrected visual acuities (BCVAs) were identified. Vitrectomy was performed as early as corneal clarity permitted. Univariate and multivariate logistic regression were used to characterize factors associated with achieving VA better than 20/40, or worse than 20/200 at 6 months.

• RESULTS: This study included 291 consecutive eyes (291 patients). LogMAR BCVA improved from 0.73 ± 0.70 before cataract surgery to 0.46 ± 0.63 ($P < .001$) after vitrectomy. The previtrectomy VA was 1.43 ± 0.79. At 6 months, 183 (62.9%) and 45 patients (15.5%) achieved BCVAs better than 20/40 and worse than 20/200, respectively. Most frequent complications were de novo ocular hypertension (29 eyes, 10%) and transient cystoid macular edema (25 eyes, 8.6%). Postvitrectomy retinal detachment occurred in 9 eyes (3.1%). Final VA of 20/40 or better was independently associated only with better precataract surgery VA, age < 75 years, absence of preexisting diabetic macular edema (DME) or postvitrectomy persistent cystoid macular edema ($P < .05$). Only poorer precataract surgery VA, delaying vitrectomy to later than 2 weeks, and final aphakic status were independently predictive of 20/200 or worse VA ($P < .05$).

• CONCLUSION: Contemporary VA outcomes of 23-gauge vitrectomy for retained lens fragments are comparable with that of prior predominantly non-MIVS cohorts, but fall short of benchmarks for uncomplicated cataract surgery. IOL type or timing of placement do not impact final VA. (Am J Ophthalmol 2020;219:271–283. © 2020 Elsevier Inc. All rights reserved.)

DISLOCATED LENS FRAGMENTS INTO THE VITREOUS cavity is an uncommon but well-recognized complication of phacoemulsification surgery, with an incidence rate ranging between 0.3% and 1.8%.[1–3] The risk factors for retained lens fragments include brunescent, mature, and posterior polar cataracts; pseudoexfoliation; small pupils; shallow anterior chamber depths; and high myopia.[4–6] Following cataract surgery, eyes with retained lens fragments have an increased risk of uveitis, glaucoma, corneal and cystoid macular edema, and retinal detachment.[1,3,7,8] With the exception of mild self-resolving cases, pars plana vitrectomy (PPV) remains the sole effective strategy to definitively remove lens fragments, reduce intraocular inflammation and pressure, and improve visual acuity.[9–12]

Microincision vitrectomy surgery (MIVS) using a trocar-cannula system is frequently used by vitreoretinal surgeons.[13,14] As of this writing, most of the major studies reporting outcomes of vitrectomy for dislocated lens fragments used 20-gauge PPV.[7,9,15–30] Thus, the surgical outcomes of MIVS, as well as the specific determinants of these outcomes, remain largely uncertain. MIVS has a lower rate of sclerotomy-related complications compared with nontrochar systems,[31,32] and it is therefore possible that this may result in improved outcomes in patients with retained lens fragments. Other industry improvements in phacoemulsification and anterior vitrectomy instrumentation may further impact final outcomes. Differences in treatment protocols for patients following complicated cataract surgery such as the optimal timings for vitrectomy after cataract surgery and for intraocular lens (IOL) implantation also have been intensively debated; however, limitations in sample size and study design have failed to resolve these issues.[3,27,29,33–35]

A comprehensive identification of prognostic determinants could help clinicians optimize outcomes. This study aims to provide a real-world contemporary perspective of the visual outcomes and complications following 23-

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gauge MIVS for retained lens fragments in a large cohort of patients, and to examine independent determinants of these outcomes.

METHODS

CONSECUTIVE PATIENTS WHO HAD COMPLICATED CATARACT surgery with retained lens fragments at the central hospital and all satellite units of Moorfields Eye Hospital (MEH) NHS Foundation Trust, that subsequently underwent PPV under the Vitreoretinal Service from October 2012 to October 2017 were identified from the electronic medical record (EMR) system, that is, OpenEyes (Across Health, Ghent, Belgium). To identify all cases of retained lens fragments that underwent PPV, we used the search terms "retained lens" OR "dropped nucleus" OR "vitrectomy" AND "fragmatome" OR "lensectomy" to generate a comprehensive list of cases. Individual records were reviewed to determine eligibility for the current analysis. The inclusion criteria were eyes that required PPV for retained lens fragments after primary cataract surgery at MEH Trust, with a minimum of 6 months' documented follow-up, and for which the primary cataract procedure was conducted also at MEH Trust. Eyes with spontaneous or traumatic crystalline lens dislocation, dislocated intraocular lens (IOL) implants, and eyes with less than 6 months of follow-up, were excluded from the study. This study received Institutional Review Board approval and adhered to the tenets of the Declaration of Helsinki.

Pre-, intra-, and postvitrectomy clinical information was collected from the medical and operative records, including patient age, gender and ethnicity, coexisting ocular conditions, and prior procedures. Precataract surgery, previtrectomy and 6-month postvitrectomy Snellen best-corrected visual acuity (BCVA) measurements were recorded.

The cause of retained lens fragments (posterior capsule rupture or zonular dehiscence), previtrectomy intraocular pressure (IOP), interval between cataract surgery and PPV, use of 20-gauge phacofragmatome, intraoperative and postoperative PPV complications, timing of IOL placement, and IOL type were also recorded. The timing of PPV after cataract surgery was analyzed according to 4 predetermined periods: within 1 week, between 1 and 2 weeks, between 2 and 4 weeks, and after 4 weeks.

Postvitrectomy IOP elevations as complications arising from PPV were defined as (1) de novo ocular hypertension (ie, IOP >25 mm Hg, at 2 or more visits) in eyes without preexisting glaucoma, and (2) in eyes with preexisting glaucoma, escalation of glaucoma therapy (ie, increase in topical medical therapy for more than 2 months, or need for new filtration surgery, or revision of existing filtration surgery). Transient cystoid macular edema (ie, central subfield thickness of more than 300 μm) was defined as intraretinal fluid that had resolved by 3 months postvitrectomy. Eyes with fluid persisting for more than 3 months were considered to have persistent cystoid macular edema.

All eyes received topical steroids and topical IOP medications following the initial presentation to the vitreoretinal emergency clinic after complicated cataract surgery as per institutional protocol. Sodium chloride 5% eye drops were administered at the ophthalmologist's discretion to improve corneal clarity. Eyes were reviewed by a vitreoretinal surgeon either on the same day or up to 2 days after the cataract procedure. In accordance with institutional practice, the main determinant of PPV timing following assessment at this clinic was the vitreoretinal surgeon's assessment of corneal clarity to safely perform a PPV. If corneal clarity was deemed insufficient, the patient was reviewed every 2 days until the cornea was ascertained to be sufficiently clear for vitrectomy. At that point, providing the IOP was controlled, the patient was listed for surgery at the next available list and seen again on the day of surgery only. If corneal clarity had not been achieved by 2 weeks, reviews were conducted every 5-7 days, until PPV. If PPV had not been performed by 1 month, the frequency of further reviews was at the discretion of the ophthalmologist. The only other factor that determined the timing of PPV when corneal clarity was suboptimal was uncontrolled IOP >35 mm Hg despite maximal topical medical therapy.

All vitrectomies were conducted using a 3-port, transconjunctival, 23-gauge PPV system from Alcon (CONSTELLATION Vision System; Alcon Laboratories Inc, Fort Worth, Texas, USA). A posterior vitreous detachment was induced at the start of surgery when required and a full vitrectomy was completed prior to addressing retained nuclear fragments. Vitrectomy was also performed in the anterior chamber to remove residual vitreous and soft lens matter if so required. The surgeon then determined if fragments could be removed with the 23-gauge cutter. If the phaco-fragmatome was required, the conjunctiva was dissected and a new 20-gauge sclerotomy formed. This was used until all nuclear fragments were removed and then sutured. Any further manipulation was then performed via the 23-gauge ports. Perfluorocarbon liquid was not used to displace or retrieve nuclear fragments. The decision to implant an IOL in the primary cataract surgery or during PPV, or at a deferred sitting, as well as IOL type, was based on the discretion of the treating ophthalmologists. A 360-scleral depressed search was conducted and any peripheral pathology was treated. Twenty-three gauge sclerotomies were sutured as required. Postvitrectomy, eyes were started on topical dexamethasone and chloramphenicol. If cystoid macular edema was present, topical nonsteroidal anti-inflammatory agents were added, with escalation to oral acetazolamide and then sub-Tenon triamcinolone for recalcitrant cases. Eyes deemed to have poor visual prognosis based on clinical assessment and eyes of patients who elected not to have further surgery were left aphakic.

The primary outcome measures were the proportion of eyes achieving BCVA of 20/40 or better, and 20/200 or worse. Secondary outcomes were the nature and incidence of postoperative complications.

Snellen VA measurements were converted to logarithm of the minimum angle of resolution (logMAR) VA for the purpose of statistical analyses. Continuous variables were expressed using the mean and standard deviation, whereas categorical parameters were described in numbers and percentages. Univariate logistic regression analyses were performed to look for associations between each variable and the primary outcomes. A multivariate logistic regression was conducted using parameters identified as significant in the univariate results.

Statistical analysis was performed with SPSS statistical analysis package, version 14.0 (SPSS Inc, Chicago, Illinois, USA), and a $P < .05$ was considered statistically significant.

RESULTS

WE IDENTIFIED 374 CONSECUTIVE PATIENTS WHO UNDERwent PPV for retained lens fragments. We excluded 12 eyes from 12 patients with traumatic lens dislocation, 26 patients with lens dislocation from inherited diseases, for example, Marfan or Stickler syndrome, 22 patients who were younger than 18 years, and 23 patients with less than 6 months' follow-up. A total of 291 eyes of 291 patients were included in the study. The total number of cataract surgeries conducted at all sites of MEH NHS Foundation Trust was 93,132 over the study period, giving an incidence of retained lens fragments of 0.31%.

Of the 291 patients, 161 (55.3%) were male, 139 (47.8%) were Caucasian, and the mean age was 73.8 ± 10.6 years. Preexisting ocular comorbidities, clinical characteristics, and prior ocular procedures are described in Table 1. Before cataract surgery, the BCVA was 20/40 or better in 115 patients (39.5%), between 20/40 and 20/200 in 102 patients (35.1%), and 20/200 or worse in 74 patients (25.4%) (Figure). The mean precataract surgery logMAR BCVA was 0.73 ± 0.70 (approximately 20/100). Eyes with exudative macular disease, that is, diabetic macular edema (DME) or wet age-related macular degeneration (AMD), had received prior intravitreal therapy until disease quiescence for at least 3 months before cataract surgery.

Retained lens fragments occurred because of posterior capsule rupture in 264 eyes (90.7%) and zonular dehiscence in the remaining 27 eyes (9.3%). There were 5 eyes (1.7%) with preexisting significant corneal disease and 30 eyes (10.3%) with preexisting macular conditions. There were 55 eyes (18.9%) that had at least 1 type of retinal pathology (ie, diabetic retinopathy, retinal vein occlusion, or prior retinal detachment), and 32 eyes (11%) with glaucoma. There were 15 (5.2%) previously vitrectomized eyes.

TABLE 1. Baseline Demographic and Clinical Characteristics

Variable	Total Cohort (n = 291)
Demographic characteristics	
Age, y, mean ± SD	73.8 ± 10.6
Male, n (%)	161 (55.3)
Left eye, n (%)	154 (52.9)
Ethnicity, n (%)	
Caucasian	139 (47.8)
African	38 (13.1)
Asian	86 (29.6)
Other ethnicities	28 (9.6)
Clinical characteristics	
Precataract surgery logMAR VA, mean ± SD	0.73 ± 0.70
Indication for fragmatome lensectomy, n (%)	
Posterior capsule rupture	264 (90.7)
Zonular dehiscence	27 (9.3)
Preexisting ocular comorbidities, n (%)	
Significant corneal pathology[a]	5 (1.7)
Significant macular pathology[b]	30 (10.3)
Any retinal pathology[c]	55 (18.9)
Glaucoma	32 (11.0)
Previtrectomy IOP (mm Hg), mean ± SD	18.8 (7.6)
Previtrectomy logMAR VA, mean ± SD	1.43 ± 0.79
Time to surgery (days), mean ± SD	8.3 ± 21.5
Prior treatment, n (%)	
Preexisting intravitreal therapy course	14 (4.8)
Prior vitrectomy[d]	15 (5.2)
Glaucoma filtration surgery	7 (2.4)

IOP = intraocular pressure, logMAR = logarithm of the minimum angle of resolution, VA = visual acuity.

[a]1 eye with keratoconus and Fuch dystrophy, 1 eye had keratoconus treated with penetrating keratoplasty, 1 eye had corneal scar from previous microbial keratitis, 1 eye had corneal blood staining, 1 eye had birth forceps injury requiring penetrating keratoplasty, which subsequently failed.

[b]12 eyes had wet age-related macular degeneration, 16 with diabetic macular edema, and 2 had prior active myopic choroidal neovascularization.

[c]41 eyes had diabetic retinopathy, 12 had previous retinal detachment, and 2 had retinal vein occlusions.

[d]11 eyes for retinal detachment and 4 eyes for diabetic vitreous hemorrhage.

The mean previtrectomy VA was 1.43 ± 0.79 (approximately 20/538), and mean previtrectomy IOP was 18.8 ± 7.6 mm Hg. The mean time from cataract surgery to PPV was 8.3 ± 21.5 days. The decision for PPV was based on a clear cornea in 288 eyes (99%), and only in 3 eyes (1%) was PPV conducted for uncontrolled IOP >35 mm Hg despite maximal medical therapy and suboptimal corneal clarity.

Of the 291 eyes, 20-gauge phacofragmentation was performed in 176 eyes (63.9%). IOL implantation was

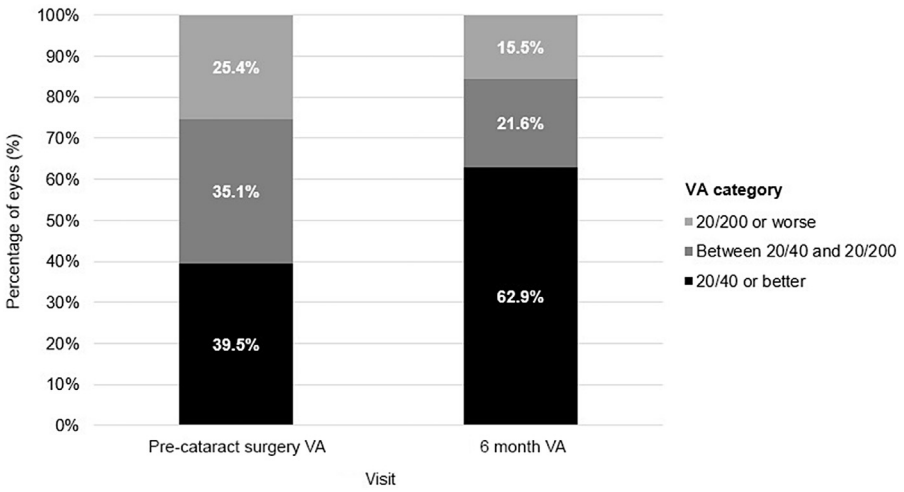

FIGURE. Precataract surgery and 6-month postvitrectomy categorical visual acuity (VA) data. Precataract surgery, 39.5%, 35.1%, and 25.4% of eyes had VA of 20/40 or better, between 20/40 and 20/200, and 20/200 or worse, respectively. At 6 months, 62.9% of the eyes achieved 20/40 or better VA, while only 21.6% and 15.5% of the eyes had VA between 20/40 and 20/200 and 20/200 or worse, respectively.

performed during the initial cataract surgery in 102 eyes (35.1%), during PPV in 87 eyes (29.9%), and after PPV in 84 eyes (28.9%) (Table 2). There were 18 eyes (6.2%) that were left aphakic. Of the 273 eyes with IOL implants, 185 (67.8%) had posterior chamber IOLs (ie, in-the-bag or sulcus placement), 71 eyes (26.0%) received anterior chamber implants, and 17 eyes (6.2%) had iris or scleral-fixated IOLs.

No eyes developed retinal detachment prior to or during their vitreoretinal surgery. During PPV, peripheral retinal pathology (tears or holes) was identified and treated with endolaser retinopexy in 5 eyes (1.7%).

Postvitrectomy VA outcomes and complications of surgery are profiled in Table 3. At the 6-month visit, the mean postvitrectomy logMAR BCVA was 0.46 ± 0.63 (approximately 20/56), with 183 eyes (62.9%) achieving better than 20/40, 63 (21.6%) with BCVA between 20/40 and 20/200, and 45 patients (15.5%) 20/200 or worse vision (Figure). There was a significant improvement in VA following vitrectomy compared with precataract and previtrectomy levels ($P < .001$ for both). The mean post-PPV IOP was 16.0 ± 4.9 mm Hg. There were 8 patients (2.7%) who developed persistent corneal edema. De novo ocular hypertension requiring initiation of glaucoma therapy was required in 26 patients, and glaucoma therapy was escalated for 17 eyes (53.1) with preexisting glaucoma (Table 3). Transient cystoid macular edema was present in 25 eyes (8.6%), and persistent cystoid macular edema in 8 eyes (2.7%). All cystoid macular edema cases showed no evidence of traction on OCT scanning. Of the 12 wet AMD eyes, all resumed regular intravitreal anti–vascular endothelial growth factor (VEGF) therapy as required. Of the 16 DME eyes, only 4 eyes (25%) required additional anti-VEGF therapy after PPV for recurrence of macular edema. There were 9 (3.1%) and 4 eyes (1.4%) that developed postvitrectomy retinal detachment and full-thickness macular holes, respectively. None of the macular holes occurred in the context of macular edema. Retinal detachment occurred at a mean of 2.2 ± 1 months (range, 1-4 months) after vitrectomy. One eye (0.3%) developed endophthalmitis. There were no cases of hypotony.

• **UNIVARIATE ANALYSES:** Compared to eyes with precataract VA of 20/40 or better, eyes with precataract VA ranging between 20/40 and 20/200 (OR 0.13, 95% CI 0.06, 0.26, $P < .001$), and eyes with VA worse than or equal to 20/200 (OR 0.09, 95% CI 0.04, 0.18, $P < .001$), were less likely to achieve 6-month VA outcomes of better than or equal to 20/40 (Table 4). Better VA outcomes at the 20/40 threshold were also less likely in patients aged ≥75 years (OR 0.47, 95% CI 0.29, 0.77, $P = .003$), in eyes with zonular dehiscence relative to those with posterior capsule rupture (OR 0.44, 95% CI 0.20, 0.97, $P = .041$), presence of wet AMD (OR 0.18, 95% CI 0.05, 0.69, $P = .012$) or DME (OR 0.25, 95% CI 0.08, 0.73, $P = .012$), prior intravitreal anti-VEGF treatments (OR 0.09, 95% CI 0.02, 0.40, $P = .002$), and if the eye had previtrectomy VA of CF or worse (OR 0.25, 95% CI 0.13, 0.48, $P < .001$) (Table 4).

At 6 months, a VA of 20/200 or worse was associated with precataract surgery BCVA of worse than 20/40 but better than 20/200 (OR 12.93, 95% CI 2.93, 57, $P = .001$), precataract surgery VA of 20/200 or worse (OR 27.12, 95% CI 6.17, 119, $P < .001$), significant corneal pathology (OR 8.71, 95% CI 1.41, 53.73, $P = .02$) (Table 4 footnote), and previtrectomy VA of CF or worse (OR 8.99, 95% CI 3.02, 26.77, $P < .001$) (Table 4).

Performing vitrectomy between 2 and 4 weeks (OR 3.91, 95% CI 1.21, 12.61, $P = .022$), or >4 weeks (OR 3.91, 95%

TABLE 2. Vitrectomy Operative Characteristics

Variable	Total Cohort (n = 291)
Phacofragmatome used, n (%)	186 (63.9)
Timing of IOL implantation, n (%)	
During primary phacoemulsification	102 (35.1)
During vitrectomy/lensectomy	87 (29.9)
After vitrectomy/lensectomy	84 (28.9)
Left aphakic	18 (6.2)
IOL type, n (%)[a]	
Sulcus PCIOL	182 (66.7)
Capsular bag PCIOL	3 (1.1)
ACIOL	71 (26.0)
Iris-fixated IOL	7 (2.6)
Scleral-fixated IOL	10 (3.7)

ACIOL = anterior chamber intraocular lens, IOL = intraocular lens, PCIOL = posterior chamber intraocular lens.
[a]Aphakic eyes not included in percentage calculations.

TABLE 3. Postvitrectomy Visual Outcomes and Complications at 6 Months

Variable	Total Cohort (n = 291)
LogMAR VA, mean ± SD	0.46 ± 0.63
Change in logMAR VA from precataract surgery, mean ± SD	−0.27 ± 0.75
IOP (mm Hg), mean ± SD	16.0 ± 4.9
Postvitrectomy complications, n (%)	
Persistent corneal edema	8 (2.7)
De novo ocular hypertension	26 (10)[a]
Escalation of glaucoma therapy	17 (53.1)[b]
Persistent CME	8 (2.7)
Transient CME	25 (8.6)
Retinal detachment	9 (3.1)
Macular hole	4 (1.4)
Endophthalmitis	1 (0.3)
Suprachoroidal hemorrhage	4 (1.4)

CME = cystoid macular edema, IOP = intraocular pressure, logMAR = logarithm of the minimum angle of resolution, VA = visual acuity.
[a]There were 259 eyes with no preexisting glaucoma.
[b]There were 32 eyes with preexisting glaucoma.

CI 1.21, 12.61, $P = .022$) following phacoemulsification, was predictive of achieving BCVA worse than 20/200 at 6 months when compared to eyes that underwent vitrectomy within the first week after cataract surgery (Table 5). Vitrectomy performed 1 to 2 weeks after cataract surgery did not demonstrate worse VA outcomes compared with vitrectomy within 1 week at the 20/40 and 20/200 levels ($P > .05$). IOL placement during vitrectomy appeared to have a poorer outcome (OR 0.48, 95% CI 0.26, 0.90, $P = .022$) than if placement was conducted during the primary phacoemulsification. Phacofragmatome use was not associated with achieving BCVA levels of 20/40 or better, or 20/200 or worse ($P = .21$ and .276, respectively). Leaving an eye aphakic was associated with poorer BCVA outcomes at both the 20/40 (OR 0.03, 95% CI 0.004, 0.22, $P < .001$) and 20/200 (OR 27.32, 95% CI 8.46, 88.25, $P < .001$) end points, compared with pseudophakic eyes. There was no difference in BCVA outcomes when comparing sulcus or in-the-bag PCIOL with other secondary IOL implants (anterior chamber lens [$P = .236$ for BCVA 20/40 or better and $P = .086$ for BCVA 20/200 or worse] and iris clip lens or scleral-fixated lens [$P = .161$ for BCVA 20/40 or better and $P = .728$ for BCVA 20/200 or worse]).

Postvitrectomy events associated with a decreased odds of achieving BCVA of 20/40 or better at 6 months were persistent cystoid macular edema (OR 0.19, 95% CI 0.04, 0.95, $P = .043$) and retinal detachment (OR 0.16, 95% CI 0.03, 0.78, $P = .024$) (Table 6). Eyes with retinal detachment were also more likely to have BCVA of 20/200 or worse (OR 12.46, 95% CI 2.99, 52, $P = .001$) at 6 months.

• **MULTIVARIATE ANALYSES:** Multivariate logistic regression (Table 7) showed that precataract surgery VA between 20/40 and 20/200, as well as of 20/200 or worse, predicted final VA at the 20/40 and 20/200 thresholds (all $P < .05$). Age ≥75 years (OR 0.31, 95% CI 0.16, 0.61, $P = .001$), preexisting DME (OR 0.21, 95% CI 0.06, 0.78, $P = .02$), aphakia (OR 0.02, 95% CI 0.002, 0.19, $P < .001$), and persistent cystoid macular edema (OR 0.08, 95% CI 0.01, 0.53, $P = .009$) were also independent predictors of VA less than 20/40 at 6 months. The following were independent predictive factors of final VA of 20/200 or worse: vitrectomy at 2-4 weeks (OR 4.89, 95% CI 1.12, 21.25, $P = .034$), vitrectomy >4 weeks (OR 4.22, 95% CI 1.04, 17.21, $P = .044$), and aphakia at 6 months (OR 21.31, 95% CI 4.80, 94.71, $P < .001$).

DISCUSSION

OUR STUDY PROVIDES CONTEMPORARY OUTCOMES OF 23-gauge MIVS for retained lens fragments after complicated cataract surgery, showing that 62.9% achieved BCVA better than 20/40, and 15.9% worse than 20/200. These outcomes do not represent an improvement over prior studies conducted in predominantly 20-gauge vitrectomy cohorts.[7,9,15–18,27–29] These outcomes are also not as good as established benchmarks in uncomplicated cataract surgery.[36–38] Although there was a low incidence of major sight-threatening complications such as retinal detachment (3.1%) and suprachoroidal hemorrhage (1.4%), more frequent and less severe complications

TABLE 4. Univariate Analysis of Precataract Surgery Factors and Previtrectomy Characteristics as Predictors of Visual Outcomes

Variable	n	VA 20/40 or Better (%)	OR (95% CI)	*P* Value	VA 20/200 or Worse (%)	OR (95% CI)	*P* Value
Precataract surgery VA							
20/40 or better	115	102 (89)	ref		2 (2)	ref	
Worse than 20/40 but better than 20/200	102	51 (50)	0.13 (0.06, 0.26)	<.001	19 (19)	12.93 (2.93, 57)	.001
20/200 or worse	74	30 (41)	0.09 (0.04, 0.18)	<.001	24 (32)	27.12 (6.17, 119)	<.001
Age, y							
Less than 75	133	96 (72)	ref		17 (13)	ref	
More than or equal 75	158	87 (55)	0.47 (0.29, 0.77)	.003	28 (18)	1.47 (0.77, 2.82)	.247
Ethnicity							
White	139	85 (61)	ref		23 (16)	ref	
Black	38	24 (63)	1.09 (0.52, 2.29)	.822	7 (18)	1.14 (0.45, 2.90)	.785
Asian	86	57 (66)	1.25 (0.71, 2.19)	.439	13 (15)	0.90 (0.43, 1.88)	.776
Other	28	17 (61)	0.98 (0.43, 2.26)	.966	2 (7)	0.39 (0.09, 1.75)	.388
Sex							
Female	130	75 (58)	ref		23 (18)	ref	
Male	161	108 (67)	1.49 (0.93, 2.41)	.100	22 (14)	0.74 (0.39, 1.39)	.346
Indication for vitrectomy/lensectomy							
Posterior capsule rupture	264	171 (65)	ref		40 (15)	ref	
Zonular dehiscence	27	12 (44)	0.44 (0.20, 0.97)	.041	5 (19)	1.27 (0.46, 3.56)	.646
Significant corneal pathology							
No	286	182 (64)	ref		42 (15)	ref	
Yes	5	1 (20)	0.14 (0.02, 1.30)	.084	3 (60)	8.71 (1.41, 53.73)	.020
Wet age-related macular degeneration							
No	279	180 (65)	ref		42 (15)	ref	
Yes	12	3 (25)	0.18 (0.05, 0.69)	.012	3 (25)	1.88 (0.49, 7.24)	.358
Diabetic macular edema							
No	275	178 (65)	ref		42 (15)	ref	
Yes	16	5 (31)	0.25 (0.08, 0.73)	.012	3 (19)	1.28 (0.35, 4.69)	.709
Myopic macular degeneration							
No	289	182 (63)	ref		45 (16)		
Yes	2	1 (50)	0.59 (0.04, 9.50)	.708	0 (0)	n/a[a]	n/a[a]
Retinal detachment before cataract surgery							
No	278	177 (64)	ref		41 (15)	ref	
Yes	13	6 (46)	0.49 (0.16, 1.50)	.210	4 (31)	2.57 (0.76, 8.73)	.131
Diabetic retinopathy							
No	249	162 (65)	ref		37 (15)	ref	
Yes	42	21 (50)	0.54 (0.28, 1.04)	.064	8 (19)	1.35 (0.58, 3.14)	.489
Retinal vein occlusion							
No	289	182 (63)	ref		44 (15)	ref	

Continued on next page

TABLE 4. Univariate Analysis of Precataract Surgery Factors and Previtrectomy Characteristics as Predictors of Visual Outcomes (*Continued*)

Variable	n	VA 20/40 or Better (%)	OR (95% CI)	*P* Value	VA 20/200 or Worse (%)	OR (95% CI)	*P* Value
Yes	2	1 (50)	0.59 (0.04, 9.50)	.708	1 (50)	5.57 (0.34, 91)	.228
Prior intravitreal therapy							
No	277	181 (65)	ref		43 (16)	ref	
Yes	14	2 (14)	0.09 (0.02, 0.40)	.002	2 (14)	0.91 (0.20, 4.20)	.901
Previtrectomy characteristics							
Previtrectomy VA							
Better than 20/200 (logMAR VA < 1)	77	60 (78)	ref		4 (5)	ref	
Worse than 20/200 but better than CF (1 ≤ logMAR VA < 2)	115	78 (68)	0.60 (0.31, 1.16)	.129	9 (8)	1.55 (0.46, 5.22)	.480
CF or worse (logMAR VA ≥ 2)	97	45 (46)	0.25 (0.13, 0.48)	<.001	32 (33)	8.99 (3.02, 26.77)	<.001
Previtrectomy IOP							
≤25 mm Hg	231	144 (62)	ref		33 (14)	ref	
>25 mm Hg	60	39 (65)	1.12 (0.62, 2.03)	.704	12 (20)	1.50 (0.72, 3.12)	.278

CF = counting fingers, CI = confidence interval, IOP = intraocular pressure, logMAR = logarithm of the minimum angle of resolution, OR = odds ratio, VA = visual acuity.
[a]Insufficient cases in one of the subcategories to conduct the statistical analysis.

included escalation of glaucoma therapy (14.7%), de novo ocular hypertension (10%), and persistent cystoid macular edema (8.4%). A comprehensive multivariate analysis in this study also showed that final visual outcome after PPV is not independently associated with IOL type, timing of IOL placement, or post-PPV complications such as IOP elevations, transient cystoid macular edema, or retinal detachment. Poorer visual outcomes were however associated with a delay in surgery of more than 2 weeks and the development of post-PPV persistent cystoid macular edema.

We compared the outcomes in our study with pooled estimates calculated from all prior major studies predominantly using 20-gauge PPV for retained lens fragments (each comprising more than 100 patients).[7,9,15–18,27–29] Ten studies involving 2,148 eyes were identified and included in the analysis. Despite the lower incidence of retinal detachment and cystoid macular edema in MIVS compared with 20-gauge cohorts, the pooled VA outcome of these studies was comparable to that of the current analysis (Supplemental Table). It is unclear why this appears to be the case given that our study indicates that persistent cystoid macular edema is a determinant of final vision in MIVS (Table 7) and as such we would have hoped to see our lower rate of cystoid macular edema translate into better visual outcomes. We are unable to ascertain as to why that might be as we do not have access to the raw data of the comparison group; however, it is possible that this reflects a selection or reporting bias of good results. There are a number of factors known to increase the incidence of macular edema, and it is possible that the lower cystoid macular edema rates seen with MIVS surgery reflect differences in clinical practice in the overall management of complicated cataract (eg, improved phacoemulsification and anterior vitrectomy instrumentation) and in the use of 23-gauge PPV. The sutureless technique and shorter surgical time with 23-gauge surgery may allow reduced intraocular inflammation. The lower retinal detachment rates in our cohort compared to that in the 20-gauge vitrectomy studies may reflect that MIVS is associated with less sclerotomy-related breaks. Although sclerostomy ports were enlarged to allow the use of the phacofragmatome, this was only performed following full vitrectomy and clearance of anterior vitreous gel at the chosen sclerotomy. The rate of retinal detachment seen in this study is indistinguishable from retinal detachment rates reported elsewhere following elective MIVS, which supports that MIVS for removal of retained lens fragments has a different risk profile to that seen in 20-gauge PPV.[39]

Although the definitions of glaucoma were not standardized across all studies, our rates of de novo ocular hypertension (10%) and escalation of glaucoma therapy (14.7%) appear much higher than in prior cohorts (Supplemental Table). Encouragingly, in the current study, IOP elevations per se did not necessarily indicate poorer VA outcomes. It is likely that transient IOP elevations are caused by

TABLE 5. Univariate Analysis of Intravitrectomy Factors as Predictors of Visual Outcomes

Variable	n	VA 20/40 or Better (%)	OR (95% CI)	*P* Value	VA 20/200 or Worse (%)	OR (95% CI)	*P* Value
Time to surgery							
Less than 1 wk	201	128 (64)	ref		25 (12)	ref	
1 wk but less than 2 wk	62	41 (66)	1.11 (0.61, 2.03)	.725	10 (16)	1.35 (0.61, 3.00)	.456
2 wk but less than 4 wk	14	7 (50)	0.57 (0.19, 1.69)	.311	5 (36)	3.91 (1.21, 12.61)	.022
4 wk or more	14	7 (50)	0.57 (0.19, 1.69)	.311	5 (36)	3.91 (1.21, 12.61)	.022
Timing of IOL implantation							
During primary phacoemulsification	102	77 (76)	ref		8 (8)	ref	
During vitrectomy	87	52 (60)	0.48 (0.26, 0.90)	.022	12 (14)	1.88 (0.73, 4.84)	.190
After vitrectomy	84	53 (63)	0.56 (0.30, 1.05)	.068	11 (13)	1.77 (0.68, 4.63)	.244
Phacofragmatome used							
No	105	71 (68)	ref		13 (12)	ref	
Yes	186	112 (60)	0.73 (0.44, 1.20)	.210	32 (17)	1.47 (0.73, 2.95)	.276
IOL type							
Sulcus IOL or capsular IOL	185	129 (70)	ref		17 (8)	ref	
ACIOL	71	44 (62)	0.71 (0.40, 1.25)	.236	12 (17)	2.01 (0.91, 4.46)	.086
Iris-fixated or scleral-fixated	17	9 (53)	0.49 (0.18, 1.33)	.161	2 (12)	1.32 (0.28, 6.25)	.728
Phakic status							
Pseudophakic	273	182 (67)	ref		31 (11)	ref	
Aphakic	18	1 (6)	0.03 (0.004, 0.22)	< .001	14 (78)	27.32 (8.46, 88.25)	<.001

ACIOL = anterior chamber intraocular lens, CI = confidence interval, IOL = intraocular lens, OR = odds ratio, VA = visual acuity.

trabeculitis and outflow obstruction from lens particles in the anterior chamber,[40] or steroid response.[41] It is also plausible that despite anterior vitrectomy for prolapsed vitreous gel in the anterior chamber, residual vitreous persisted causing outflow obstruction. A delay in PPV surgery could also account for the IOP elevation as several authors noted higher rates of secondary glaucoma with later surgery than same-day surgery.[18,42,43] Wilkinson and Green provided a clinicopathologic perspective by the observation of increased lens particle-induced inflammatory cells with delay in surgery, suggesting a potential benefit of earlier PPV.[44] Thus, a comprehensive and separate investigation of factors associated with de novo ocular hypertension and escalation of glaucoma therapy is currently being undertaken by our group.

Post-PPV macular holes have been previously reported.[45] The macular holes in our series were large, showed no cystoid changes at the margins of the hole, and in some cases had overhanging edges (Supplemental Figure). In all these cases, the phacofragmatome had been used. Development of macular hole following phacofragmatome has not been described previously. It is possible that this occurred at the time of PVD induction or as a result of direct trauma from transmitted ultrasonic energy from a nonoccluded fragmatome port.

Persistent cystoid macular edema remains a key predictor of poorer visual outcomes in 23-gauge PPV for retained lens fragments despite medical management with topical steroids and nonsteroidal anti-inflammatory drugs. A major limitation of treatment escalation with intravitreal depot dexamethasone (ie, Ozurdex) is the lack of a posterior capsule that might allow anterior migration of the implant. The treatment of recalcitrant cystoid macular edema is evolving with the potential use of immunomodulatory agents, including infliximab and interferon alpha[46,47]; however, the management remains challenging. This study suggests that further investigations into the prevention and management of post-PPV cystoid macular edema would be of benefit.

A final aphakic status was associated with VA outcomes of 20/200 or worse. This largely reflects a clinical or patient decision not to have secondary lens insertion when the prognosis was poor in the current study, for example, geographic atrophy or macular scarring. Other complications observed in patients with visual acuity of less than 20/200 included macular pathology such as macular hole and retinal detachment involving the macula. Although each of these complications were not shown to be determinants of functional outcomes individually, this is likely to be due to the small numbers involved. Our results indicate that it is of clinical interest to reduce these complications to optimize visual results.

Our study indicates that patients having surgery more than 2 weeks after complicated cataract surgery have worse visual outcomes compared with more timely surgery. This might reflect upregulation of adverse inflammatory mediators and pathways that occurs around this time,[48] potentially leading to worse outcomes. The optimal timing of PPV after

TABLE 6. Univariate Analysis of Postvitrectomy Complication as Predictors of Visual Outcomes

Variable	n	VA 20/40 or Better (%)	OR (95% CI)	*P* Value	VA 20/200 or Worse (%)	OR (95% CI)	*P* Value
Persistent cystoid macular edema							
No	283	181 (64)	ref		44 (16)	ref	
Yes	8	2 (25)	0.19 (0.04, 0.95)	.043	1 (13)	0.78 (0.09, 6.46)	.815
Transient cystoid macular edema							
No	266	168 (63)	ref		42 (16)	ref	
Yes	25	15 (60)	0.88 (0.38, 2.02)	.755	3 (12)	0.73 (0.21, 2.54)	.616
Retinal detachment							
No	282	181 (64)	ref		39 (14)	ref	
Yes	9	2 (22)	0.16 (0.03, 0.78)	.024	6 (67)	12.46 (2.99, 52)	.001
Persistent corneal edema							
No	283	183 (65)	ref		42 (15)	ref	
Yes	8	0 (0)	n/a[a]	n/a[a]	3 (38)	3.44 (0.79, 14.95)	.099
De novo glaucoma in eyes with no preexisting glaucoma[b]							
No	233	149 (64)	ref		34 (15)	ref	
Yes	26	14 (54)	0.66 (0.29, 1.49)	.314	6 (23)	1.76 (0.66, 4.69)	.261
Escalation of glaucoma in eyes with preexisting glaucoma[c]							
No	18	12 (67)	ref		2 (11)	ref	
Yes	14	8 (57)	0.67 (0.16, 2.82)	.582	3 (21)	2.18 (0.31, 15.29)	.432
Endophthalmitis							
No	290	183 (63)	ref		44 (15)	ref	
Yes	1	0 (0)	n/a[a]	n/a[a]	1 (100)	n/a[a]	n/a[a]
Iatrogenic macular hole							
No	287	183 (64)	ref		43 (15)	ref	
Yes	4	0 (0)	n/a[a]	n/a[a]	2 (50)	5.67 (0.78, 41.37)	.087
Suprachoroidal hemorrhage							
No	287	183 (64)	ref		43 (15)	ref	
Yes	4	0 (0)	n/a[a]	n/a[a]	2 (50)	5.67 (0.78, 41.37)	.087

CI = confidence interval, IOL = intraocular lens, OR = odds ratio, VA = visual acuity.
[a]Not enough cases in one of the subcategories to conduct statistical analysis.
[b]There were 259 eyes with no preexisting glaucoma.
[c]There were 32 eyes with preexisting glaucoma.

complicated cataract surgery has been intensively debated and as of this writing there is still no consensus.[3,27,29,33,34] Vanner and associates conducted a meta-analysis and systematic review involving more than 50 cohorts, and observed a general trend for better visual outcomes and reduced complication rates (including retinal detachment and IOP elevation) when PPV was conducted earlier.[35] They concluded that vitrectomy performed within the first week was preferred. In a large cohort of 569 eyes, Modi and associates reviewed the timing of PPV (same day, within 1 week, and later than 1 week) and found no differences in visual outcomes and surgical complications between all 3 groups.[15] In both these and other prior studies, the impact of delaying PPV to specifically more than 2 weeks after cataract surgery was not analyzed.[24]

In this study, the timing of PPV was based on institutional practice allowing surgeon assessment of corneal clarity to be the primary arbiter for time to surgery. Corneal clarity per se was not a determinant of poor visual outcomes as long as surgery could be completed within 2 weeks. These results are based on a multivariate analysis, which seeks to remove the confounding effect of other markers of severity, on the association between time to vitrectomy and VA outcomes, but we cannot exclude the possibility of selection bias that might reflect the influence of other comorbidities or surgeon factors. The results indicate that efforts to prevent and hasten reduction of corneal edema (eg, topical sodium chloride 5%, intensive treatment of anterior uveitis), in order that PPV can be performed within 2 weeks, may be important to improve outcomes.

Our analysis suggests that neither the timing of IOL placement nor IOL type (sulcus or capsular-bag posterior chamber IOL, anterior chamber, iris- or scleral-fixated IOLs) impacted VA outcomes, contrasting with some prior

TABLE 7. Multivariate analysis of Predictive Factors of Visual Outcomes

Variable	VA 20/40 or Better[a]		VA 20/200 or Worse[a]	
	OR (95% CI)	*P* Value	OR (95% CI)	*P* Value
Precataract surgery VA				
20/40 or better	ref		ref	
Worse than 20/40 but better than 20/200	0.14 (0.06, 0.32)	<.001	7.83 (1.57, 39.07)	.012
20/200 or worse	0.12 (0.05, 0.31)	<.001	14.53 (2.89, 73.11)	.001
Age				
Less than 75	ref		—	
More than or equal 75	0.31 (0.16, 0.61)	.001	—	—
Prior intravitreal therapy				
No	ref		—	
Yes	0.23 (0.03, 1.51)	.126	—	—
Preexisting significant corneal pathology				
No	—		ref	
Yes	—	—	5.02 (0.38, 66.17)	.220
Preexisting wet age-related macular degeneration				
No	ref		—	
Yes	0.52 (0.08, 3.16)	.476	—	—
Preexisting diabetic macular edema				
No	ref		—	
Yes	0.21 (0.06, 0.78)	.020	—	—
Previtrectomy VA categories				
Better than 20/200 (logMAR $<$ 1)	ref		ref	
Worse than 20/200 but better than 20/2000 (1 $\leq$ logMAR $<$ 2)	0.76 (0.33, 1.79)	.537	0.86 (0.22, 3.35)	.826
20/2000 or worse (2 $\leq$ logMAR)	0.46 (0.19, 1.14)	.093	3.05 (0.85, 11.01)	.088
Indication for vitrectomy/lensectomy				
Posterior capsule rupture	ref		—	
Zonular dehiscence	0.47 (0.18, 1.25)	.131	—	—
Time to surgery				
Less than 1 wk	—		ref	
1 wk but less than 2 wk	—	—	1.75 (0.61, 5.01)	.294
2 wk but less than 4 wk	—	—	4.89 (1.12, 21.25)	.034
4 wk or more	—	—	4.22 (1.04, 17.21)	.044
Timing of IOL implantation				
During primary phacoemulsification	ref		—	
During vitrectomy	0.58 (0.26, 1.33)	.201	—	—
After vitrectomy	0.61 (0.22, 1.66)	.334	—	—
Phakic status				
Pseudophakic	ref		ref	
Aphakic	0.02 (0.002, 0.19)	.001	21.31 (4.80, 94.71)	<.001
Retinal detachment				
No	—		ref	
Yes	—	—	6.49 (0.89, 47.54)	.066
Persistent cystoid macular edema				
No	ref		—	
Yes	0.08 (0.01, 0.53)	.009	—	—

ACIOL = anterior chamber intraocular lens, CI = confidence interval, IOL = intraocular lens, OR = odds ratio, VA = visual acuity.

[a]Dashes indicate that the variable was not significant in the univariate analysis for this outcome and was not included in the multivariate analysis model.

studies.[18,27] Ho and associates showed that PCIOL placement at the time of cataract surgery predicted better final vision,[18] and Scott and associates demonstrated that eyes with an IOL placed had better final VAs.[27] These formed the basis of recommendations to place an IOL, if at all possible. However, the timing of IOL placement is probably merely a surrogate marker for the severity of complications. IOL placement during cataract surgery is only usually possible when the complications during cataract surgery are only in eyes with less severe complicated cataract surgery and if there is enough capsular support. If capsule rupture occurred later in the cataract procedure (ie, during epinucleus or cortical removal), there may remain sufficient capsular support to place an IOL in the sulcus or bag. These eyes would likely also have less vitreous loss,[48] and conceivably a lower likelihood of adverse postoperative outcomes (eg, corneal edema, elevated IOP, and uveitis).

The main limitation of this study is the retrospective study design, and thus selection bias could have been introduced. Although decisions on PPV timing were based on ascertainment of corneal clarity, physician preferences based on vitreous loss, uveitis severity, and nucleus size also may be confounders for the association between PPV timing and VA outcome. The retrospective study design precluded accurate collection of such data. Other potential surrogate markers that we could measure such as previtrectomy IOP did not show any difference.

In conclusion, data from this large cohort of eyes suggests that 23-gauge MIVS currently achieves comparable VA outcomes as 20-gauge surgery in eyes with retained lens fragments. These eyes have poorer VA outcomes than eyes with uncomplicated cataract surgery. Similar VA outcomes were achieved among eyes in our study when PPV is performed within 2 weeks of cataract surgery. Significantly more eyes in this cohort had poor VA of worse than 20/200 if PPV was conducted more than 2 weeks after cataract surgery.

CRediT AUTHORSHIP CONTRIBUTION STATEMENT

ERROL W. CHAN: CONCEPTUALIZATION, METHODOLOGY, Formal analysis, Data curation, Writing - original draft, Writing - review & editing. **Elizabeth Yang:** Conceptualization, Methodology, Formal analysis, Data curation, Writing - original draft, Writing - review & editing. **Mohab Eldeeb:** Conceptualization, Methodology, Formal analysis, Data curation, Writing - original draft, Writing - review & editing. **James W. Bainbridge:** Conceptualization, Methodology, Formal analysis, Data curation, Writing - original draft, Writing - review & editing. **Lyndon da Cruz:** Conceptualization, Methodology, Formal analysis, Data curation, Writing - original draft, Writing - review & editing. **Paul S. Sullivan:** Conceptualization, Methodology, Formal analysis, Data curation, Writing - original draft, Writing - review & editing. **Mahi M. Muqit:** Conceptualization, Methodology, Formal analysis, Data curation, Writing - original draft, Writing - review & editing. **David G. Charteris:** Conceptualization, Methodology, Formal analysis, Data curation, Writing - original draft, Writing - review & editing. **Miriam Minihan:** Conceptualization, Methodology, Formal analysis, Data curation, Writing - original draft, Writing - review & editing. **Eric Ezra:** Conceptualization, Methodology, Formal analysis, Data curation, Writing - original draft, Writing - review & editing. **Louisa Wickham:** Conceptualization, Methodology, Formal analysis, Data curation, Writing - original draft, Writing - review & editing.

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REFERENCES

1. Tajunisah I, Reddy SC. Dropped nucleus following phacoemulsification cataract surgery. *Med J Malaysia* 2007;62(5):364–367.
2. Leaming DV. Practice styles and preferences of ASCRS members—1994 survey. *J Cataract Refract Surg* 1995;21(4):378–385.
3. Gilliland GD, Hutton WL, Fuller DG. Retained intravitreal lens fragments after cataract surgery. *Ophthalmology* 1992;99(8):1263–1267. discussion 8–9.
4. Ergun SB, Kocamis SI, Cakmak HB, Cagil N. The evaluation of the risk factors for capsular complications in phacoemulsification. *Int Ophthalmol* 2018;38(5):1851–1861.
5. McKelvie J, Laurent C. Applying risk analysis to predict posterior capsule rupture during cataract surgery in New Zealand. *Clin Exp Ophthalmol* 2016;44(9):861–864.
6. Narendran N, Jaycock P, Johnston RL, Taylor H, Adams M, Tole DM, et al. The Cataract National Dataset electronic multicentre audit of 55,567 operations: risk stratification for posterior capsule rupture and vitreous loss. *Eye (Lond)* 2009;23(1):31–37.
7. Margherio RR, Margherio AR, Pendergast SD, et al. Vitrectomy for retained lens fragments after phacoemulsification. *Ophthalmology* 1997;104(9):1426–1432.
8. Lambrou FH Jr, Stewart MW. Management of dislocated lens fragments during phacoemulsification. *Ophthalmology* 1992;99(8):1260–1262. discussion 8–9.
9. Vilar NF, Flynn HW Jr, Smiddy WE, Murray TG, Davis JL, Rubsamen PE. Removal of retained lens fragments after phacoemulsification reverses secondary glaucoma and restores visual acuity. *Ophthalmology* 1997;104(5):787–792.

10. Ruiz-Moreno JM, Barile S, Montero JA. Phacoemulsification in the vitreous cavity for retained nuclear lens fragments. *Eur J Ophthalmol* 2006;16(1):40–45.
11. 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(12):2106–2110.
12. Fastenberg DM, Schwartz PL, Shakin JL, Golub BM. Management of dislocated nuclear fragments after phacoemulsification. *Am J Ophthalmol* 1991;112(5):535–539.
13. Stuart A. The progress of minimally invasive vitreous surgery. *EyeNet Magazine*. Available at https://www.aao.org/eyenet/article/progress-of-minimally-invasive-vitreous-surgery. Accessed December 30, 2019.
14. Jumper JM, Mittra RA, eds. ASRS 2012 Preferences and Trends Membership Survey. Chicago, IL: American Society of Retina Specialists; 2012.
15. Modi YS, Epstein A, Smiddy WE, Murray TG, Feuer W, Flynn HW Jr. Retained lens fragments after cataract surgery: outcomes of same-day versus later pars plana vitrectomy. *Am J Ophthalmol* 2013;156(3):454–459.
16. Olsson RB, Ritland JS, Bjørnsson OM, Syrdalen P, Eide N, Overgård R. A retrospective study of patients with retained nuclear fragments after cataract surgery. *Acta Ophthalmol Scand* 2000;78(6):677–679.
17. Borne MJ, Tasman W, Regillo C, Malecha M, Sarin L. Outcomes of vitrectomy for retained lens fragments. *Ophthalmology* 1996;103(6):971–976.
18. 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(4):587–594.e1.
19. Baker PS, Spirn MJ, Chiang A, et al. 23-gauge transconjunctival pars plana vitrectomy for removal of retained lens fragments. *Am J Ophthalmol* 2011;152(4):624–647.
20. Horozoglu F, Yanyali A, Macin A, Nohutcu AF, Keskinbora KH. 23-Gauge transconjunctival sutureless vitrectomy for retained lens fragments after complicated cataract surgery. *Retina* 2012;32(3):493–498.
21. Barthelmes D, Alexander S, Mitchell P, Chandra J. Hybrid 20/23-gauge pars plana vitrectomy for retained lens fragments after cataract surgery. *Retina* 2012;32(9):1749–1755.
22. Scupola A, Abed E, Sammarco MG, et al. 25-Gauge pars plana vitrectomy for retained lens fragments in complicated cataract surgery. *Ophthalmologica* 2015;234(2):101–108.
23. 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(4):427–432.
24. Chalam KV, Murthy RK, Priluck JC, Khetpal V, Gupta SK. Concurrent removal of intravitreal lens fragments after phacoemulsification with pars plana vitrectomy prevents development of retinal detachment. *Int J Ophthalmol* 2015;8(1):89–93.
25. Lashgari A, Kabiri M, Ramezani A, et al. Visual and anatomical outcomes of pars plana vitrectomy for dropped nucleus after phacoemulsification. *J Ophthalmic Vis Res* 2018;13(3):253–259.
26. Ghasemi Falavarjani K, Hashemi M, Jalili Fazel A, Modarres M, Nazari H, Parvaresh MM. Pars plana vitrectomy and intravitreal phacoemulsification for dropped nuclei. *J Ophthalmic Vis Res* 2012;7(2):125–129.
27. Scott IU, Flynn HW Jr, Smiddy WE, et al. Clinical features and outcomes of pars plana vitrectomy in patients with retained lens fragments. *Ophthalmology* 2003;110(8):1567–1572.
28. 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(5):570–575.
29. Smiddy WE, Guererro JL, Pinto R, Feuer W. Retinal detachment rate after vitrectomy for retained lens material after phacoemulsification. *Am J Ophthalmol* 2003;135(2):183–187.
30. Merani R, Hunyor AP, Playfair TJ, et al. Pars plana vitrectomy for the management of retained lens material after cataract surgery. *Am J Ophthalmol* 2007;144(3):364–370.
31. Scartozzi R, Bessa AS, Gupta OP, Regillo CD. Intraoperative sclerotomy-related retinal breaks for macular surgery, 20- vs 25-gauge vitrectomy systems. *Am J Ophthalmol* 2007;143(1):155–156.
32. Yokota R, Inoue M, Itoh Y, Rii T, Hirota K, Hirakata A. Comparison of microinsicion vitrectomy and conventional 20-gauge vitrectomy for severe proliferative diabetic retinopathy. *Jpn J Ophthalmol* 2015;59(5):288–294.
33. Stefaniotou M, Aspiotis M, Pappa C, Eftaxias V, Psilas K. Timing of dislocated nuclear fragment management after cataract surgery. *J Cataract Refract Surg* 2003;29(10):1985–1988.
34. Al-Khaier A, Wong D, Lois N, Cota N, Yang YC, Groenewald C. Determinants of visual outcome after pars plana vitrectomy for posteriorly dislocated lens fragments in phacoemulsification. *J Cataract Refract Surg* 2001;27(8):1199–1206.
35. Vanner EA, Stewart MW. Vitrectomy timing for retained lens fragments after surgery for age-related cataracts: a systematic review and meta-analysis. *Am J Ophthalmol* 2011;152(3):345–357.
36. Donachie PHJ, Sparrow JM. National Ophthalmology Database Audit: year 3 annual report—the second prospective report of the National Ophthalmology Database Audit. Available at ; 2018. https://www.nodaudit.org.uk/u/docs/20/avusuryktz/NOD%20Audit%20Annual%20Report%202018.pdf;. Accessed July 6, 2019.
37. Lundström M, Barry P, Henry Y, Rosen P, Stenevi U. Visual outcome of cataract surgery; study from the European Registry of Quality Outcomes for Cataract and Refractive Surgery. *J Cataract Refract Surg* 2013;39(5):673–679.
38. Sparrow JM, Taylor H, Qureshi K, et al. The Cataract National Dataset electronic multi-centre audit of 55,567 operations: risk indicators for monocular visual acuity outcomes. *Eye (Lond)* 2012;26(6):821–826.
39. Essex RW, Hunyor AP, Moreno-Betancur M, et al. The visual outcomes of macular hole surgery: a registry-based study by the Australian and New Zealand Society of Retinal Specialists. *Ophthalmol Retina* 2018;2(11):1143–1151.
40. Epstein DL, Jedziniak JA, Grant WM. Obstruction of aqueous outflow by lens particles and by heavy-molecular-weight soluble lens proteins. *Invest Ophthalmol Vis Sci* 1978;17(3):272–277.
41. Phulke S, Kaushik S, Kaur S, Pandav SS. Steroid-induced glaucoma: an avoidable irreversible blindness. *J Curr Glaucoma Pract* 2017;11(2):67–72.

42. Blodi BA, Flynn HW Jr, Blodi CF, Folk JC, Daily MJ. Retained nuclei after cataract surgery. *Ophthalmology* 1992;99(1):41–44.
43. Chen CL, Wang TY, Cheng JH, Tai MC, Lu DW, Chen JT. Immediate pars plana vitrectomy improves outcome in retained intravitreal lens fragments after phacoemulsification. *Ophthalmologica* 2008;222(4):277–283.
44. Wilkinson CP, Green WR. Vitrectomy for retained lens material after cataract extraction: the relationship between histopathologic findings and the time of vitreous surgery. *Ophthalmology* 2001;108(9):1633–1637.
45. Rahman W, Georgalas I, da Cruz L. Macular hole formation after vitrectomy for retinal detachment. *Acta Ophthalmol* 2010;88(4):e147–e148.
46. Deuter CM, Gelisken F, Stubiger N, et al. Successful treatment of chronic pseudophakic macular edema (Irvine-Gass syndrome) with interferon alpha: a report of three cases. *Ocul Immunol Inflamm* 2011;19(3):216–218.
47. Wu L, Fernando Arevalo J, Hernandez-Bogantes E, Roca JA. Intravitreal infliximab for refractory pseudophakic cystoid macular edema: results of the Pan-American Collaborative Retina Study Group. *Int Ophthalmol* 2012;32(3):235–243.
48. Ti SE, Yang YN, Lang SS, Chee SP. A 5-year audit of cataract surgery outcomes after posterior capsule rupture and risk factors affecting visual acuity. *Am J Ophthalmol* 2014;157(1):180–185.e1.