Original Article

Intraocular pressure reduction in a spectrum of angle closure disease following cataract extraction

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Purpose: The purpose is to study the effect of cataract extraction on intraocular pressure (IOP) in patients with angle closure disease (ACD). **Methods:** In this retrospective study, patients with ACD including medically uncontrolled and advanced primary angle closure glaucoma (PACG) who underwent only cataract surgery were included. The IOP trend was analyzed at postoperative day 1, day 7, 1 month, 3 months, 6 months, 1 year, and final follow-up along with requirement of antiglaucoma medication (AGM)/surgery. **Results:** A total of 110 eyes of 79 patients [primary angle closure suspect (PACS): 21, PAC: 34, PACG: 55 eyes] were analyzed. Of these patients, 31 eyes had advanced PACG and 20 eyes had medically uncontrolled glaucoma. Best-corrected visual acuity >6/12 was seen in 51 eyes at baseline and 87 eyes at final follow-up. After cataract surgery alone, there was significant reduction (median) in IOP [19.1 ± 18.00% (18.8) in PACS ($P < 0.01$), 8.55 ± 17.9% (10) in PAC ($P = 0.04$), 22.82 ± 15.45%(14.3) in PACG ($P < 0.01$), 18.27 ± 15.99% (14.5) in advanced PACG ($P = 0.01$) and 36.56 ± 14.58% (28.57) in medically uncontrolled glaucoma ($P < 0.01$)] and AGM [51.85% (1) in PAC, 32.35% (2) in PACG, 17.71% (2) in advanced PACG, and 40.74% (1.5) in medically uncontrolled PACD] at median follow-up of 1, 2.5, 1, 1.3, and 1 year. Eleven PACG patients, who were on systemic medication preoperatively, were off systemic therapy at final follow-up, while six other PACG eyes (10.9%) required glaucoma surgery. **Conclusion:** Cataract surgery leads to significant drop in IOP across the spectrum of ACD with visually significant cataract. Cataract surgery may be considered initially for IOP control even in advanced or medically uncontrolled PACG followed by glaucoma surgery later if required.

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Angle closure disease (ACD) is recognized as a major public health problem, particularly in Asia and China. According to a recent meta-analysis by Tham *et al*.,[1] Asia is likely to have the greatest number of people with primary angle closure glaucoma (PACG) by 2040, an increment of 9.0 million (58.4%) from 2013.

The underlying pathogenesis of ACD is multifactorial. Crystalline lens has been implicated in its etiology. With advancing age the lens thickness increases and it is positioned more anteriorly, increasing the incidence of angle closure in predisposed eyes.[2]

The role of early lens extraction in early angle closure has been documented in various studies.[2] In advanced angle closure glaucoma, phacotrabeculectomy is generally preferred.[3] The combined procedure is also preferred in advanced glaucoma patients, to avoid early postoperative intraocular pressure (IOP) spikes which may aggravate the preexisting optic nerve damage.

Cataract surgery is a simpler procedure as compared to combined phacotrabeculectomy, which also requires more complex postoperative management and is associated with higher rate of complications. The beneficial effects of cataract surgery alone in advanced ACD have not been studied adequately. In this study, we looked at the effect of cataract extraction alone on IOP across the spectrum of ACD including patients with advanced optic nerve damage.

Methods

This study was a retrospective analysis of records of patients of ACD with cataract presenting to a tertiary care center. The eyes included in the study had undergone cataract surgery alone after informed consent. Institutional Ethics Committee approval was obtained for analysis and reporting of this work.

Each patient had undergone comprehensive ophthalmic examination. The diagnosis of glaucoma was made on the basis of IOP, gonioscopy, disc evaluation, and visual field analysis. International Society for Geographical and Epidemiological Ophthalmology (ISGEO) classification[4] was followed to classify the patients of primary ACD (PACD) into three categories: primary angle closure suspect (PACS),

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primary angle closure (PAC), and primary angle closure glaucoma (PACG). We further looked into three subsets of PACDs:

- Early-to-moderate PACG: The eyes with signs of angle closure, cup–disc ratio <0.8 with corresponding early-to-moderate visual field defects according to Hodapp–Parrish–Anderson criteria[5]
- Advanced PACG: The eyes with signs of angle closure, advanced glaucomatous neuropathy (cup–disc ratio of 0.9—total cupping with diffuse neuroretinal rim loss), and corresponding advanced visual field defects according to Hodapp–Parrish–Anderson criteria[5]
- Medically uncontrolled PACD: The eyes not achieving target IOP with more than three topical antiglaucoma medications (AGM) or requiring systemic antiglaucoma therapy to achieve target IOP were labeled as medically uncontrolled angle closure glaucoma irrespective of stage of glaucoma.

Any cataract—nuclear opalescence, posterior subcapsular cataract, or cortical cataract—impairing the best-corrected visual acuity (BCVA) to ≤20/50 or affecting daily activities was considered significant. These patients underwent cataract extraction alone irrespective of their ISGEO classification, extent of peripheral anterior synechiae (PAS), or amount of glaucoma damage.

Patients with PACG where IOP was not well controlled were given the choice of undergoing cataract surgery alone or combined phacoemulsification with trabeculectomy, with the understanding that glaucoma surgery could be done later if required. Data from patients who consented for cataract surgery alone were analyzed, and no randomization was done.

All patients with preexisting glaucoma surgery except laser iridotomy/iridoplasty (LI) were excluded. The patients with minimum follow-up of <6 months were excluded.

The PACG patients were given oral acetazolamide 250 mg (Tab. acetazolamide 250 mg; Tab. diamox 250 mg, Wyeth Holdings Corporation, USA) on the day of surgery and continued till next morning to take care of any postoperative IOP spike. The IOP was monitored in the follow-up period and dose of AGM was adjusted accordingly.

The IOP trend was analyzed at postoperative day 1, day 7, 1 month, 3 months, 6 months, 1 year, and at final follow-up along with requirement of AGM/surgery. The IOP spikes were assessed by the number of eyes having IOP >21 mmHg on postoperative day 1. Their data were analyzed for visual acuity, long-term IOP control, and visual field changes over the follow-up.

The statistical analysis was carried out using Statistical Package for the Social Sciences (SPSS version 22, IBM, New York, USA). Normality of the quantitative data was checked by Kolmogorov–Smirnov test. Distributions were summarized using proportions, means ± SD, or medians/interquartile range, as appropriate. The change in parameters such as visual acuity, IOP at baseline, and final visit was analyzed using Wilcoxon signed-rank test. One-way analysis of variance test was used for computing significant association in quantitative parameters between the groups. A significance level of 5% was used. Correlations were computed using Pearson correlation.

Results

Demography

A total of 79 patients (110 eyes) that fulfilled the inclusion criteria were analyzed. This included 21 eyes of PACS, 34 eyes of PAC, and 55 eyes of PACG patients, of which 31 eyes had advanced PACG. Twenty eyes had medically uncontrolled glaucoma. We had more females than males (48:31) in our study. The mean age at surgery was 62.86 ± 8.74 years.

Preoperative parameters

Visual acuity

While analyzing visual acuity, 51 eyes had BCVA Snellen equivalent (SE) >6/12, 45 eyes had BCVA between Snellen equivalent 6/12–6/60, nine eyes had BCVA ranging between Snellen equivalent 6/60 to hand motion close to face, while five eyes had only perception of light.

Intraocular pressure

The mean preoperative IOP in PACS was 16.38 ± 3.67 mmHg without any AGM, whereas the mean IOP in PAC and PACG patients was 15.44 ± 3.33 mmHg on 1.35 ± 0.69 AGM and 17.53 ± 5.65 mmHg on 2.72 ± 1.22 AGM, respectively. The advanced PACG group had an IOP of 17.13 ± 5.37 mmHg on 2.71 ± 1.22 AGM. The medically uncontrolled glaucoma group had an IOP of 20.5 ± 7.40 mmHg on 4.050 ± 0.65 AGM. Eleven PACG patients were on systemic drugs (Tab. acetazolamide 250 mg three times a day) preoperatively.

Other parameters

The mean vertical cup–disc ratio was 0.65 ± 0.22. Thirty-one eyes had cup–disc ratio of 0.9—total cupping. The mean axial length was 22.56 ± 0.95 mm. Sixty-four eyes had previous patent LI (PACS: 7; PAC: 23; PACG: 34). There was no significant difference in drop of IOP from baseline to final follow-up in PACS ($P = 0.26$), PAC ($P = 0.48$), and PACG patients ($P = 0.35$) who underwent LI before cataract surgery and who were taken up directly for cataract surgery. Similarly, there was no significant reduction in medication from baseline in the group with preexisting LI and who did not have LI before cataract surgery in both PAC ($P = 0.08$) and PACG subsets ($P = 0.21$).

Three eyes had intraoperative posterior capsule rupture (PCR), which was successfully managed with anterior vitrectomy and IOL was placed in the sulcus. Two eyes belonged to PAC group, while one eye belonged to PACS group. None of the PACG eyes had PCR. One eye had developed aqueous misdirection in immediate postoperative period which later required surgery.

Postoperative parameters

Visual acuity

At final follow-up, the eyes having BCVA of Snellen equivalent >6/12 increased to 87 eyes. Sixteen eyes had BCVA of Snellen equivalent between 6/12 and 6/60, two eyes had Snellen equivalent of 6/60 to hand motion close to face, while fie eyes had perception of light only.

Intraocular pressure

Overall, there was 22.82% reduction in IOP and 38.60% reduction in medication at a mean follow-up of 2.68 ± 2.71 (median: 1 year) years. The mean preoperative and final follow-up IOP, across the spectrum, was 16.73 ± 4.98 and

13.75 ± 2.73 mmHg, respectively. Maximum reduction in IOP at final follow-up was seen in medically uncontrolled PACDs group (36.58%), whereas minimum IOP reduction was seen in PAC group (8.55%) as compared to their preoperative IOP. The mean number of AGM (oral + topical) on preoperative and final follow-up, across the spectrum, was 2.17 ± 1.21 and 1.38 ± 1.21, respectively. Maximum benefit in terms of reduction in AGM was seen in PAC (51.85% reduction) and early-to-moderate PACG (50.92% reduction) groups. Table 1 summarizes the preoperative and final IOP and AGM requirement in all groups along with percentage reduction in IOP and AGM.

The trend of mean IOP and topical AGM at preoperative, day 1, day 7, 1 month, 3 months, 6 months, 1 year, and final follow-up in PACS, PAC, PACG (early-to-moderate PACG, advanced PACG) and medically uncontrolled glaucoma is given in Figs. 1-3.

Twenty PACDs patients had medically uncontrolled IOP, of which 11 patients were on systemic medication before cataract extraction. All those patients who had preoperative systemic medication were weaned off in postoperative period at final follow-up. There was 36.58% reduction in IOP and 40.7% reduction in number of AGM at final follow-up [Table 1]. Four patients were medically uncontrolled at final follow-up (requiring >3 topical drugs), three out of them had their IOP in the target range on four AGM and one required glaucoma surgery.

Intergroup trend

There was significant drop of IOP from baseline in PACG when compared to PAC subset at final follow-up ($P = 0.04$) but no significant reduction in number of medication ($P = 0.65$). There was no significant drop in IOP from baseline in early and moderate glaucoma when compared to advanced glaucoma ($P = 0.24$) but there was higher reduction in number of AGM in the early-to-moderate PACG group as compared to advanced glaucoma ($P = 0.02$).

Postoperative IOP spikes

The IOP >21 mmHg was seen in 10 (18.18%) out of 55 PACG eyes on first postoperative day (mean: 27 mmHg, range: 22–40 mmHg), of which six eyes had cup–disc ratio of

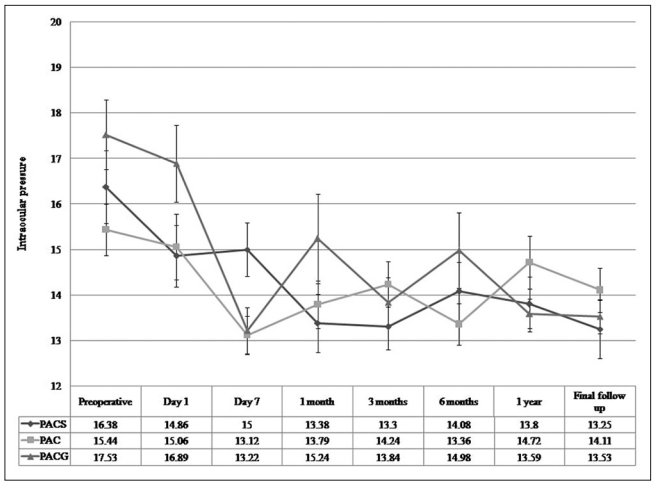

Figure 1: IOP trend during follow-up in all subsets of PACD (Error bars: Standard error of mean)

Table 1: Overview of the preoperative and final IOP along with antiglaucoma drugs across the spectrum of ACD

Group	Preoperative IOP	IOP at final follow-up	Percentage reduction in IOP (median)	*P*	Mean drugs at baseline	Mean drugs final follow-up	Percentage reduction in AGM (median)	Mean follow-up after surgery (years) mean±SD (median)	*P*
PACS *n*=21	16.38±3.67	13.25±2.95	19.1% (18.8)	<0.01	0	0	0	2.19±2.83 (1)	<0.01
PAC *n*=34	15.44±3.33	14.11±2.77	8.55% (10)	0.04	1.35±0.69	0.65±0.85	51.85% (1)	3.10±2.57 (2.5)	<0.01
PACG *n*=55	17.53±5.65	13.53±2.71	22.82% (14.3)	<0.01	2.72±1.22	1.84±1.18	32.35% (2)	2.6±2.76 (1)	<0.01
Early- moderate PACG *n*=24	18.04±6.08	12.92±2.59	28.38% (19.6)	<0.01	2.71±1.24	1.33±1.05	50.92% (1)	1.79±1.86 (1)	<0.01
Advanced PACG *n*=31	17.13±5.37	14±2.74	18.27% (14.5)	0.01	2.71±1.22	2.23±1.15	17.71% (2)	3.14±3.17 (1.3)	0.02
Medically uncontrolled PACDs, *n*=20	20.5±7.40	13±2.99	36.58% (28.57)	<0.01	4.05±0.66	2.4±1.27	40.74% (1.5)	1.85±1.99 (1)	<0.01

PACS=Primary angle closure suspect, PAC=Primary angle closure, PACG=Primary angle closure glaucoma, PACDs=Primary angle closure diseases

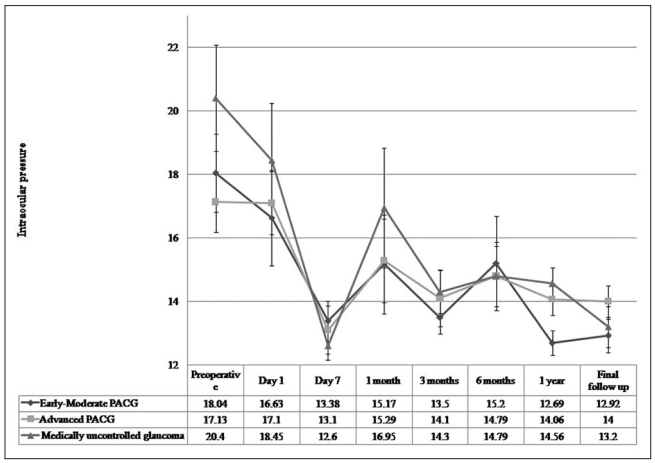

Figure 2: IOP trend during follow-up in early–moderate PACG, advanced PACG, and medically uncontrolled glaucoma (Error bars: Standard error of mean)

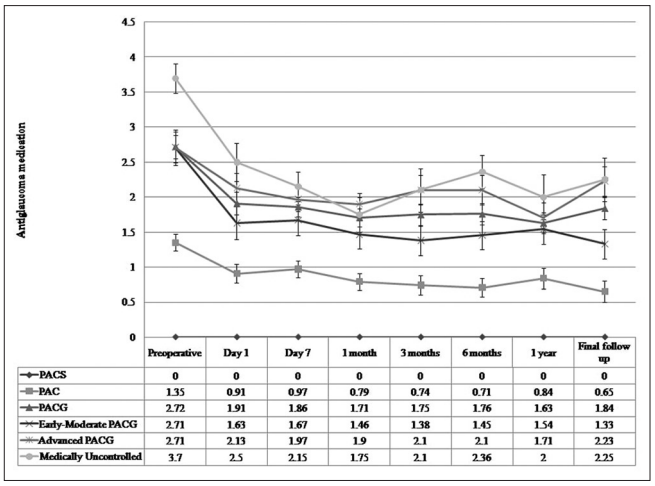

Figure 3: Antiglaucoma medication requirement during follow-up in all subsets of PACD including early–moderate PACG, advanced PACG, and medically uncontrolled glaucoma (Error bars: Standard error of mean)

0.9—total cup. Out of 20 eyes with medically uncontrolled glaucoma, six (30%) eyes had postoperative IOP spike. Four eyes had IOP >25 mmHg on day 1. These eyes underwent anterior chamber paracentesis (wound burping). The remaining eyes were managed with topical and/or oral AGM. Out of patients who had IOP spikes, four eyes had BCVA (Snellen equivalent visual acuity) of 6/12, four eyes had BCVA ≥6/60 to ≤6/18, while two eyes had only perception of light in the preoperative period. Postoperatively, seven eyes had BCVA of ≥6/12, one eye had BCVA of 6/18, and one had vision of counting finger at 2 m, while one eye had perception of light only. Two eyes required glaucoma surgery during the follow-up. On visual fields, the average "mean deviation" at preoperative and final visit was −18.46 ± 10.47 and −14.26 ± 9.67 dB; while the mean "pattern standard deviation" at preoperative and final visit was 5.99 ± 2.67 and 6.70 ± 4.25 dB, respectively.

Requirement of AGM and glaucoma filtration surgery

None of the patients, who were not on AGM preoperatively, required it in postoperative period. Out of 88 PAC and PACG eyes, 50 (56.81%) that were on AGM preoperatively required significantly smaller number of medications in postoperative period, 28 eyes (31.81%) required same number of medications, while 10 eyes (11.33%) required higher number of topical medications in the follow-up period compared to preoperative AGM. Six (10.9%) eyes out of 55 PACG eyes required glaucoma filtration surgery during the follow-up. Five eyes had advanced glaucomatous damage, while one eye had moderate glaucoma preoperatively. The eye with moderate glaucoma developed malignant glaucoma and required anterior vitrectomy followed by glaucoma drainage device implantation in postoperative period. The rest of five eyes underwent surgery because their IOP was not in target range during the follow-up.

The preoperative IOP significantly correlated with drop in IOP between preoperative and final visit (correlation coefficient = −0.86, $P < 0.001$) [Table 2]. Neither the axial length correlated with drop in IOP between baseline and final visit ($P = 0.08$) nor there was any correlation between preoperative and postoperative IOP at final follow-up ($P = 0.82$).

Table 2: Cumulative preoperative IOP and drop in IOP between baseline and final visit for all subsets of ACD

Preoperative IOP	Number of eyes	Drop in IOP
≥31 mmHg	4	−20.5±5.26
22-30	12	−8.83±3.76
≤21 mmHg	94	−1.51±3.51

IOP=Intraocular pressure

Discussion

Beneficial effects of cataract extraction on IOP have been reported in early and moderate ACD.[2] In the present study all patients had undergone cataract surgery alone irrespective of the extent of PAS. The amount of PAS usually decreases after phacoemulsification in patients with PACG. A study by Lai *et al*. showed that percentage of eyes with synechial angle closure > 270° decreased from 43% before surgery to 24% after phacoemulsification.[6]

We found overall 22.82% reduction in IOP and 38.61% reduction in medication on mean follow-up of 2.68 ± 2.71 years (median: 1 year) in all subset of ACD. Chen *et al*. in their meta-analysis reported 13–37% drop in IOP and 18–77% reduction in medication in chronic PACG patients at mean follow-up of 6–25.7 months.[7] The overall percentage reduction in IOP appears to be low in our study because most of our patients were on medication before cataract surgery and majority of them had their IOP controlled on multiple medication (90/110); therefore, percentage reduction in IOP attributable to cataract surgery is likely to be higher than what our data suggested. The maximum IOP reduction was seen in PACG patients (22.82%) followed by PACS (19.1%) and then PAC (8.55%). The small percentage of IOP reduction seen in PAC may be because most of them were controlled on medication before surgery. However, significant reduction in number of AGM was also maximum in PAC group (51.85%) followed by early–moderate PACG (50.92%) and medically uncontrolled glaucoma patients (40.7%). We also found significant reduction in IOP and medications in advanced

PACG eyes (18.27% reduction in IOP and 17.71% reduction in medication) at mean follow-up of 3.14 years (median: 1.3 years).

The IOP reduction was higher in PACG compared to PAC, because higher drop is expected in patients with higher preoperative IOP. This might suggest that there is equally beneficial effect of cataract extraction on IOP control in PACG, though PAC patients had a higher drop in number of AGM but it was not significantly different from PACG. Early-to-moderate glaucoma group had similar IOP reduction but higher reduction in AGM compared to advanced PACG group, which may be attributable to poor residual trabecular meshwork function in latter.

Foster *et al*. have compared IOP reduction in PACG ($n = 36$) and PAC ($n = 19$) eyes and found significant drop of IOP in PACG eyes (5.6 vs. 2.5 mmHg). Our PACG eyes also showed higher drop of IOP compared to PAC eyes (4.00 vs. 1.33 mmHg) but it was less profound than the former study which could be due to small sample size and short follow-up of the study by Foster *et al*. (mean follow-up: 7 months).[8] We also looked at the IOP reduction at 6 months follow-up and found that it was similar to that reported in former study (5.55 vs. 2.21 mmHg).

We found higher drop in IOP at final follow-up in eyes having high IOP preoperatively, which was in concordance with a study by Foster *et al*.[8] In our cohort of medically uncontrolled glaucoma, 11 patients were on systemic therapy preoperatively (including four patients who had IOP >31 mmHg on maximum topical and oral medication). All these patients were weaned off systemic therapy at final follow-up. There was 39.19% reduction in number of AGM.

Many studies have advocated phacotrabeculectomy in advanced or uncontrolled PACG patients with cataract.[9,10] Tham *et al*. concluded in their study that combined phacotrabeculectomy may be marginally more effective than phacoemulsification alone in controlling IOP in medically controlled CACG eyes with coexisting cataract. However, after adjusting eyes that had persistent hypotony in the phacotrabeculectomy group, there was no significant difference in the two groups.[10] They also did a randomized control trial comparing phacoemulsification and phacotrabeculectomy in medically uncontrolled PACG and found that mean IOP was significantly lower in combined surgery group vs. phacoemulsification alone (13.6 vs. 15.9 mmHg at 18 months) with 1.25 times lesser requirement of topical AGM at 24 months follow-up. However, on using a different definition of "medically controlled," they found that both the groups attained >90% IOP control at 1 and 2 years after the surgery and there was no statistically significant difference between the two study arms at these two time points.[11] Moreover, combined surgery was associated with more postoperative complications in both the studies and more progression of optic neuropathy.[10,11]

Trabeculectomy and phacotrabeculectomy in PACG pose challenges as they are associated with number of complications. The rate of complications in PACG patients undergoing phacotrabeculectomy has been reported to be much higher than phacoemulsification alone (26.2 vs. 8.1%, respectively), while there was no difference in visual acuity or glaucoma progression during 24 months follow-up period.[12] We encountered posterior capsular tear in 3 out of 110 eyes, which was managed successfully with anterior vitrectomy and implantation of IOL in the sulcus. There was no choroidal detachment or shallow anterior chamber postoperatively. One patient developed aqueous misdirection in the postoperative period who later on required surgical intervention.

Another point of concern while performing phacoemulsification alone is risk of postoperative spikes in IOP. The IOP spike >21 mmHg was seen in 18.2% of PACG eyes ($n = 10$ eyes) on first postoperative day, of which six eyes had advanced glaucoma. Only two eyes had an IOP spike of >30 mmHg. The IOP spike was managed with anterior chamber paracentesis in four eyes and rest were managed with oral and topical AGM. The reported incidence of IOP spike ranges from 6 to 21%.[6,8,13-16] Most of the studies have not given any prophylaxis for immediate postoperative IOP spike. We gave oral acetazolamide 250 mg in all our PACG patients as a prophylaxis for IOP spikes.

Six out of 55 PACG eyes (10.90%) required glaucoma surgery during mean follow-up of 2.67 ± 2.76 years (median: 1 year). The reported rate of requirement of glaucoma filtration surgery after phacoemulsification alone for control of IOP in literature varies from 0 to 3% in medically controlled PACG eyes,[10,13,17] whereas in medically uncontrolled PACG the requirement was higher ranging from 16 to 20% at mean follow-up of 1–2 years.[11,18] Fewer eyes needed glaucoma filtration surgery (10.9%) in our study. Even on assessing the medically uncontrolled PACG eyes, only 1 out of 20 eyes (5%) required glaucoma filtration surgery.

The recent guidelines by American Academy of Ophthalmology have advocated cataract extraction in medically controlled PACG eyes with coexisting cataract,[7] but in PACG eyes with advanced glaucomatous neuropathy/medically uncontrolled glaucoma, it is still a matter of debate that phacoemulsification alone or combined phacotrabeculectomy should be performed.

We found significant reduction in IOP after cataract extraction alone in all the groups of PACG, including patients with advanced glaucomatous neuropathy as well as medically uncontrolled glaucoma subset. There is a risk of transient acute elevation in IOP after cataract surgery. However, it can be managed effectively by prompt intervention and perioperative systemic therapy. Most patients continued to have a sustained IOP lowering following cataract surgery as only 10.9% of our PACG patients required glaucoma filtration surgery during follow-up. Therefore, phacoemulsification alone can be considered as initial procedure even in advanced or medically uncontrolled PACD eyes having cataract before glaucoma filtration surgery or combined procedure.

Conclusion

Cataract surgery leads to significant reduction in IOP across the spectrum of ACD. In patients with visually significant cataract with advanced or medically uncontrolled PACG, cataract surgery alone may therefore be considered for primary intervention, followed by glaucoma surgery later if required.

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Conflicts of interest

There are no conflicts of interest.

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