Original article

Effect of phacoemulsification surgery on various parameters in patients with glaucoma

Sanjeeb Bhandari,[1] Indira Paudyal,[1] Shankar Prasad Khanal,[2] Suman S Thapa[1]
[1]Tilganga Institute of Ophthalmology, Gaushala, Bagmati Bridge,
[2]Central Department of Statistics, Tribhuvan University
Kathmandu, Nepal

Abstract

Background: Cataract and glaucoma are both common conditions and are often present in the same patient. The incidence of these diseases increases with age. Besides vision impairment, these diseases are associated with decrement in quality of life (QOL). **Objective:** To study the effect of phacoemulsification surgery on various parameters in patients with glaucoma. **Materials and methods**: We enrolled 50 eyes of 36 patients with glaucoma and concomitant cataract scheduled for phacoemulsification cataract surgery . A record was made which included number of anti-glaucoma medications, visual acuity (VA), intra-ocular pressure (IOP), anterior chamber depth (ACD), cataract category/grade, visual field (VF) analysis (mean deviation (MD) and pattern standard deviation (PSD) and responses to Indian visual function questionnaires (IND-VFQ). The patients were re-evaluated at one month after cataract extraction and the above parameters were again obtained to compare them with the firs values. **Results**: The mean age of the patients was 66.34 yrs ± 7.96; 10 eyes (20 %) had angle closure and 40 (80 %) had open angle glaucoma. Following cataract extraction, VA improved, IOP decreased, number of glaucoma medications decreased and AC depth increased. The VF analysis showed that the improvement in MD was significant while changes in PSD were not. The improvements seen in the visual function questionnaires (VFQ) were significant. When these parameters were analyzed based on the types of glaucoma, in the angle closure glaucoma (ACG) group, the decrease of IOP from 15.30 ± 6.18 to 12.70 ± 2.71 was not significant (p = 0.24). In the open angle glaucoma (OAG) group, the changes in the number of anti-glaucoma medication were not significant. When the parameters were analyzed in subgroups, based on cataract category, nuclear sclerosis and posterior sub-capsular, the VA improved significantly in both and the MD improved in the posterior sub-capsular surgery. Improvement in VFQ's was observed in denser nuclear sclerotic and posterior subcapsular cataracts. **Conclusion:** Cataract extraction results in significant improvement in vision, IOP reduction, decrease in the number of medications, deepening of AC and in the quality of life in patients with co-existing glaucoma when the cataract is of significant density.

Keywords: Glaucoma, cataract, quality of life

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Address for correspondence
Dr Sanjeeb Bhandari, MD
Tilganga Institute of Ophthalmology
Gaushala, Bagmati Bridge, Kathmandu, Nepal
Phone: +977 - 9851150866
Email: san_bhan@hotmail.com

Introduction

Glaucoma affected 60.5 million people in 2010 and is estimated to increase to 79.6 million by 2020. It is the second leading cause of blindness worldwide, disproportionately affecting women

and Asians (Quigley, 1996). In Nepal, a recent population-based survey reported the prevalence of glaucoma to be 1.9 % (Thapa et al, 2012).

Many patients with glaucoma develop cataract as a result of advancing age. Cataract causes blurring of image, scattering of light and a decrease in illumination (Zuckerman et al, 1973). This results in diminution of visual acuity (VA) and a diffuse depression on visual fields (VF) in an otherwise normal individual. Discerning relative contributions of cataract and glaucoma on VA and VF in patients with both conditions is a common challenge for clinicians.

Computerized VF testing with automated perimetry is a well-established and essential tool in the diagnosis and long-term management of glaucoma. The Humphrey Field Analyzer (Humphrey Instruments, Inc, San Leandro, California) is now the most commonly used automated perimeter. The mean deviation (MD) compares the average difference between the patient's sensitivities and age-matched control values. The pattern standard deviation (PSD) is a global measure of VF loss that takes into account any diffuse VF loss that may occur from lens opacities and pupillary constriction, and quantifies the differences of sensitivities among different locations of the same field. The effect of simulated cataract on glaucomatous visual field has been shown to significantly worsen the MD index while inducing no changes in indexes designed to identify focal deficits in the visual field (Budenz & Feuer et al, 1993). Cataract extractions with intraocular lens placement in eyes with glaucoma have resulted in a decrease of the intraocular pressure (IOP) (Ge et al, 2001; Hayashi et al, 2001; Euswas et al, 2005; Lai et al, 2006; Tham et al, 2008; Mathalone et al, 2005; Shingleton et al, 2006) and an improvement in the MD. However, the PSD results have varied among the studies (Smith et al, 1997; Chen et al, 1998; Hayashi et al, 2001, Koucheki et al, 2004; Musch et al, 2006, Siddiqui et al, 2007; Ang et al, 2010; Rao et al, 2013).

Clinical indicators such as VA impairment and VF defects have been standard measures to describe visual disabilities associated with cataract and glaucoma. The patients' subjective assessment of their visual function and self-perceived, vision-related quality of life (QOL), which can be achieved by simple questionnaires with relevant questions, is an important outcome measure that can reflect the impact of these eye diseases. However, these types of QOL assessments have not been widely used in daily clinical practice and relatively such few studies have been reported (Clemons et al, 2003; Wu et al, 2008).

In this study, we evaluated the short-term effect of phacoemulsification cataract extraction on VA, IOP, VF and QOL in glaucoma patients with co-existing cataract.

Materials and methods

In this interventional case series, consecutive patients with glaucoma and visually-significant cataract scheduled for phacoemulsification cataract surgery between September 2010 and December 2011, from the glaucoma clinic of Tilganga Institute of Ophthalmology, Kathmandu were included. Patients with (i) any known retinal or neuro-ophthalmic pathology that could produce visual field loss, (ii) previous intra-ocular surgery other than trabeculectomy, (iii) postoperative IOP > 21mm Hg and glaucoma progression after surgery as indicated by worsening of MD > 2 dB (iv) perimetric false negative and fixation loss indices consistently more than 33 %, and perimetric false positives greater than 15 %, were excluded.

The enrolled patients underwent a detailed evaluation which included the number of anti-glaucoma medication, VA assessment (ETDRS),

VF assessment (using the threshold central standard 24-2 program in Humphrey visual Field Analyzer, Humphrey Instruments, CA, USA) and an interview with the Indian visual field questionnaires (IND-VFQ) (Gupta et al, 2005). Ophthalmological examination with slit-lamp bio-microscope (Haag Streit BQ 900) included grading of peripheral anterior chamber depth (ACD) (Van Herrick's), IOP with Goldmann applanation tonometer and gonioscopy with 4 mirror Zeiss gonioscope. The angle was graded as open, occludable, or occluded according to definitions proposed by ISGEO (Foster et al, 2002). The lens was examined after pupillary dilatation (unless contra-indicated) and the cataract was graded (WHO cataract grading group). For this study, cataracts were categorized as either predominantly nuclear sclerotic or predominantly posterior sub-capsular. Predominantly nuclear sclerotic cataracts had minimal or no posterior sub-capsular opacities and minimal cortical opacities (in the periphery). Predominant posterior sub-capsular cataracts had significant central posterior sub-capsular opacities with minimal or no nuclear sclerosis (grade 1 or less). The ACD was measured with pentacam (Lackner et al, 2005). After one month of phacoemulsification cataract surgery, the patients were re-evaluated and a record of the number of antiglaucoma medications, VA, ACD, VF and response to VFQ was made.

Statistics

Statistical analyses were performed using the statistical software STATA 9.0 (Stata Corp, College Station, Tex). The changes in the average value of the continuous outcome variables before and after surgery were evaluated with the paired t-test or Wilcoxon signed rank test, whichever was applicable.

A written informed consent was obtained from the participants enrolled in this study.

Ethical clearance was obtained from the institutional review board (IRB) of the Tilganga Institute of Ophthalmology.

Results

A total of 50 eyes from 36 patients (72 % females) were studied. The mean age was 66.34 (± 7.96) years. The patient demographics are shown in Table 1. There were 10 eyes with angle closure glaucoma. Two had received trabeculectomy surgery in the past and the remaining had patent peripheral iridotomy.

Table 1: Patient Demographics

No. of eyes		50
No. of patients		36
Female (%)		26 (72%)
Right eye		27
Age (Years)		
Mean ± SD	**66.34 ± 7.96**	
Median	**66**	
Range	**50 – 80**	
Glaucoma		
Primary angle closure	**10 (20%)**	
Primary open angle	**40 (80%)**	

All eyes underwent phacoemulsification cataract extraction surgery with posterior chamber intra-ocular lens implantation. Forty-nine eyes (98 %) were re-assessed during the follow-up.

The resultant change in the number of glaucoma medications, VA, ACD, IOP, visual field and visual function questionnaire scores is shown in Table 2.

Table 2. The resultant change in the number of medications, VA, ACD, IOP, visual field and VFQ

Characteristics	Pre-operative Mean ± SD	Post-operative Mean ± SD	P value
No. of medications	1.42 ± 0.73	1.31 ± 0.69	< 0.05[a]
Visual acuity(VA) (logMAR)	0.52 ± 0.26	0.07 ± 0.12	< 0.0001[b]
Anterior chamber depth (ACD)	2.30 ± 0.35	3.80 ± 0.56	< 0.0001[b]
IOP (in mm Hg)	14.56 ± 3.75	12.73 ± 2.11	< 0.001[a]
Visual Field Analysis			
MD (dB)	– 11.51 ± 7.45	– 10.48 ± 7.43	< 0.005[a]
PSD (dB)	6.67 ± 4.02	7.15 ± 3.93	0.3056[a]
VFQ score			
General functioning	37.7 ± 11.85	26.69 ± 4.80	< 0.001[a]
Psychosocial Impact	6.7 ± 2.73	5.0 ± 1.47	< 0.001[a]
Visual function	14.06 ± 4.84	9.51 ± 2.76	< 0.001[a]

[a] P value calculated form Wilcoxon signed-rank test.
[b] P value from paired *t* test.

MD = mean deviation in dB
PSD = Pattern Standard deviation
VFQ = Visual function questionnaire

Phacoemulsification cataract surgery was associated with improvement in VA, decrease in the number of anti-glaucoma medications, increase in ACD, decrease in IOP and improvement in all domains of VFQ, all changes were statistically significant (Table 2). When VF was analyzed, there was a significant improvement in the MD but the PSD did not change significantly.

Table 3: The resultant change in the number of medications, VA, ACD, IOP, VF and VFQ score among angle closure glaucoma (n = 10)

Characteristics		Pre-operative	Post-operative	P value
No. of medications	Mean ± SD	1.50 ± 0.97	0.89 ± 0.60	< 0.05[a]
	Median	1	1	
	Range	1 – 4	0 – 2	
Visual acuity (logMAR)	Mean ± SD	0.43 ± 0.24	0.07 ± 0.15	< 0.001[a]
	Median	0.39	0	
	Range	0.18 – 1	0 – 0.48	
Anterior chamber depth (ACD)	Mean ± SD	2.00 ± 0.49	3.50 ± 0.58	< 0.0001[b]
	Median	1.78	3.4	
	Range	1.68 – 3.3	2.6 – 4.19	
IOP (in mm Hg)	Mean ± SD	15.30 ± 6.18	12.70 ± 2.71	0.24[a]
	Median	13	12.5	
	Range	8 – 28	9 – 18	
Visual Field Analysis				
MD (dB)	Mean ± SD	– 9.43 ± 7.96	– 9.20 ± 7.42	0.88[a]
PSD (dB)	Mean ± SD	4.52 ± 3.70	5.02 ± 2.76	0.45[a]
Visual function questionnaire				
General functioning	Mean ± SD	34.5 ± 6.73	26.6 ± 4.03	< 0.001[a]
Psychosocial Impact	Mean ± SD	5.9 ± 1.52	5.0 ± 1.25	< 0.05[a]
Visual function	Mean ± SD	11.60 ± 3.89	9.3 ± 2.75	0.073[a]

[a] P value calculated form Wilcoxon signed-rank test.
[b] P value from paired *t* test.

MD = Mean deviation
PSD = Pattern Standard deviation

Changes among glaucoma sub-groups

When changes were analyzed between the two groups, the following observations were noted. In the angle closure group, cataract extraction was associated with a decrease in the number of anti-glaucoma medications, improvement in VA, deepening of anterior chamber and improvement in VFQ's, which were significant. Though there was a decrease in the IOP following surgery, it was not statistically significant. There was no change in the VF either (Table 3).

In the open angle group, improvement in VA, deepening of ACD, decrease in IOP and improvement in VFQ's were clinically significant. The VF showed a significant improvement in the MD but improvement in the PSD was insignificant. In this group, following cataract surgery, there was insignificant change in the number of anti-glaucoma medications (Table 4).

Table 4: The resultant changes in the number of medications, VA, ACD, IOP, VF and VFQ among open angle glaucoma(n = 40)

Characteristics		Pre-operative	Post-operative	P value
No. of medications	Mean ± SD	1.40 ± 0.67	1.41 ± 0.68	> 0.05[a]
	Median	1	1	
	Range	1 – 4	1 – 4	
Visual acuity (logMAR)	Mean ± SD	0.54 ± 0.26	0.07 ± 0.12	< 0.0001[a]
	Median	0.6	0	
	Range	0.18 – 1.3	0 – 0.48	
Anterior chamber depth (ACD)	Mean ± SD	2.37 ± 0.26	3.89 ± 0.54	< 0.0001[b]
	Median	2.35	3.9	
	Range	1.86 – 2.82	2.95 – 4.7	
IOP (in mm Hg)	Mean ± SD	14.37 ± 2.94	12.74 ± 1.98	< 0.001[a]
	Median	14	12	
	Range	9 – 22	10 – 18	
Visual Field Analysis				
MD (dB)		– 12.03 ± 7.32	– 10.81 ± 7.49	< 0.005[a]
PSD (dB)		7.20 ± 3.96	7.70 ± 4.02	0.39[a]
Visual function questionnaire				
General functioning		38.5 ± 12.75	26.72 ± 5.03	< 0.001[a]
Psychosocial Impact		6.9 ± 2.73	5.0 ± 1.54	< 0.001[a]
Visual function		14.67 ± 4.89	9.56 ± 2.79	< 0.001[a]

[a] P value calculated form Wilcoxon signed-rank test.
[b] P value from paired *t* test.
MD = Mean deviation
PSD = Pattern Standard deviation

Comparison among types and grades of cataract

When the mean changes were compared based on the type of cataract, changes in VA were significant, irrespective of the cataract category and grades while changes in MD were not. Improvement in the mean scores following surgery on the different domains of the VFQ's was not significant in the nuclear sclerosis grade I cataract but became significant with the worsening of nuclear sclerosis (grade II and grade III) and in posterior subcapsular cataract (Table 5).

Table 5: The mean changes in VA[1], MD[2], PSD[3], and VFQ's[4] after phacoemulsification with IOL implantation sorted by preoperative values

Cataract (Types & grade)	VA	MD	PSD (p value)	General Functioning (p value)	Psychosocial Impact (p value)	Visual Functioning (p value)
Nuclear Sclerosis I	0.24 (p^a<0.005)	1.29 (p^a=0.14)	0.21 (p^a=0.71)	10 (p^a=0.06)	1 (p^a=0.09)	3.5 (p^a=0.06)
Nuclear Sclerosis II	0.37 (p^a<0.0001)	0.56 (p^a=0.39)	-0.47 (p^a=0.39)	11.08 (p^a<0.001)	1.37 (p^a<0.005)	4 (p^a<0.005)
Nuclear Sclerosis III	0.61 (p^a<0.05)	1.86 (p^a=0.09)	0.60 (p^a=0.67)	7.62 (p^a<0.05)	1.5 (p^a<0.05)	4 (p^a<0.05)
Posterior Subcapsular	0.55 (p^a<0.001)	1.75 (p^a<0.05)	-1.46 (p^a=0.17)	13.43 (p^a<0.005)	2.53 (p^a<0.005)	6.04 (p^a<0.005)

[1] Visual acuity in logMAR(with "-" sign)
[2] Mean deviation(with "-" sign)
[3] Pattern standard deviation
[4] Visual function questionnaires which comprises of 3 subgroups viz; general functioning, psychosocial impact & visual functioning.
[a]p value from Wilcoxon signed rank test.

Discussion

Glaucoma is a slowly progressive and irreversible disease characterized by morphological changes in the optic disc, retinal nerve fiber layer and associated defects in the visual field. Detection and monitoring of this blinding disease requires structural and functional changes, but it is only via functional measurements that one can quantify the visual status. Cataract and glaucoma are common conditions and often present in the same patient. Besides vision impairment, both of these diseases are associated with decrement in the QOL (Wu et al, 2008).

Improvement in VA seen in the entire cohort and in all subgroups suggests that following cataract surgery, VA improves significantly irrespective of the pre-operative VA status, type of glaucoma and cataract category and/or its grade.

Improvement in VA was accompanied by a decrease in IOP. Various authors have studied the IOP lowering effect of cataract surgery (Table 6). After cataract extraction, IOP decreases irrespective of the glaucoma types and studies with a higher mean preoperative IOP showed a greater decrease in the mean IOP postoperatively, while those with a lower mean preoperative IOP showed a lower mean IOP reduction. Typically, eyes with ACG have a higher preoperative IOP and a greater IOP reduction. In our study, though angle closure group demonstrated reduction in the IOP, it was not significant. This could be because of a lower mean IOP prior to surgery and the effect of a smaller sample size.

Table 6: Mean IOP reductions after phacoemulsification with IOL implantation sorted by preoperative IOP.

			IOP (mm Hg)		
Study*	Glaucoma type	Eyes (n)	Preoperative (mean)	Postoperative (mean)	change
Ge et al, 2001	ACG	47	25.5	12.0	- 13.5
Hayashi et al, 2001	ACG	73	21.4	15.0	- 6.4
Euswas et al, 2005	ACG	48	22.0	17.1	- 4.9
Lai et al, 2006	ACG	21	19.7	15.5	- 4.2
Tham et al, 2008	ACG	25	16.3	14.5	- 1.8
Present	ACG	10	15.3	12.7	- 2.6
Hayashi et al, 2004	OAG	73	20.5	16.4	- 4.4
Mathalone et al, 2005	OAG	58	17	15.1	- 1.9
Shingleton et al, 2006	OAG	55	18.4	16.6	- 1.8
Present	OAG	40	14.4	12.7	- 1.7

ACG = angle closure glaucoma, OAG = open angle glaucoma, IOP = Intraocular pressure , * First author

Reduction in IOP following surgery led to a decreased number of anti-glaucoma medications in cohort with angle closure glaucoma. This also puts emphasis on the role of cataract extraction in patients with angle closure glaucoma consistent with the study of Euswas et al, 2005 and Lai et al, 2006. On the other hand, the mean change in the number of anti-glaucoma medications in patients with open angle glaucoma was not statistically significant, despite a significant reduction in the IOP following surgery. In this study, the majority of the open angle glaucoma consisted of "normal tension" glaucoma. Hence, to prevent inadvertent damage, the number of anti-glaucoma medications might not have decreased following surgery.

Cataract extraction was associated with a significant deepening of the AC irrespective of the type of glaucoma and category/grades of cataract. Before surgery, the AC depth in eyes with angle closure glaucoma was much smaller [mean 2 (± 1.78 SD)] than in eyes with open angle glaucoma [mean 2.37 (± 0.26 SD)]. However, following surgery, the AC depth in both groups was identical, 3.50 (± 0.58 SD) and 3.89 (± 0.54 SD) respectively, as seen in the study of Ge et al, 2001 and Hayashi et al, 2001. Replacing cataract with an IOL increased the mean ACD from 2.80 mm to 3.80 mm. The clinical implication of this finding indicates that cataract surgery can remove the anatomic cause for angle closure glaucoma.

There have been several studies on the effect of age-related lens growth (Mann, 1957; Tripathi et al, 1982; Strenk et al; 2010). The anterior lens surface moves forward with age, shallowing the anterior chamber and displacing the ciliary body and iris root anteriorly. Lens exchange returns the anterior segment to the position it was earlier in life. Because the implanted artificial lens does not enlarge over time, a lower IOP can be maintained thereafter.

The MD and PSD are the most popular global indices used in clinical practice with conventional full-threshold white-on-white perimetry. Several studies have evaluated the effects of cataract on white-on-white perimetry in normal subjects and in patients with glaucoma (Smith et al, 1997; Chen et al, 1998; Hayashi et al, 2001, Koucheki et al, 2004; Musch et al, 2006, Siddiqui et al, 2007; Ang et al, 2010; Rao et al, 2013). These studies have shown an improvement in the MD as in this study, but the results of the changes in the PSD are conflicting. In our study, a deterioration of PSD occurred, which was not significant ($p = 0.3$).

The differences in the density of scotoma among patients in these studies might be the possible reason for these conflicting results. Hayashi et al in 2001 have in fact reported that the PSD deteriorated in VFs with dense scotoma whereas it remained unchanged in VFs with less dense scotoma. They hypothesized that relatively less scotoma resulting from cataract decreased after surgery whereas dense scotoma remained virtually unchanged, leading to enhanced asymmetry of the glaucomatous field defects after cataract extraction and a worsening of the PSD.

When cataract was segregated into predominantly nuclear sclerotic and posterior sub-capsular, the mean improvement in the MD was not significant for nuclear sclerotic whereas for the posterior sub capsular, it was significant. This finding is consistent with observations of Stewart et al (1995) and Carrillo et al (2005) who have noticed the MD to be unaffected by nuclear cataracts. The possible reasons hypothesized for the insignificant improvement in the MD after cataract extraction are minimal cataract and advanced VF defects with little scope for improvement (Chen et al, 1998; Koucheki et al, 2004). In our study, cataract was

less dense and glaucoma less advanced [mean MD: -11.48], which could result in minimal changes in the MD following surgery. On the other hand, with posterior sub-capsular cataract, extraction of the cataract resulted in a significant improvement in the MD, consistent with the findings of Rao et al (2013).

Cataract is associated with psychological distress, vision-related disability and QOL. Studies have shown that subjects with age-related cataract and glaucoma have an associated decrease in QOL and vision function, independent of presenting visual acuity in the better eye (Clemons et al, 2003; Wu et al, 2008).

Impaired QOL due to cataract in patients with glaucoma can be explained in our study by significant improvement in responses to the VFQs following surgery. This improvement was observed in all three components of the VFQ, in the entire cohort, as well as in both the groups viz, angle closure and open angle glaucoma. Gupta et al with the same questionnaires as in our study had observed a significant improvement in all three components of the VFQ in cohorts with glaucoma. Significant improvement in QOL was also observed in patients with glaucoma with co-existent cataract following cataract extraction by Musch et al (2006) using vision-specific quality of life (VS-QOL) questionnaires.

When considering different categories and grades of cataract, the VFQs did not show significant changes in the group that had cataract of less density, despite significant improvement in the VA. This could be because this group had a relatively better vision prior to the cataract extraction. With progression in the cataract density, the mean changes became increasingly significant. In cohort with posterior sub-capsular opacities, following cataract surgery, improvement in the mean scores of VFQs was significant.

This study has a number of limitations. The number of patients in the angle closure group was small. During follow-up, cases were revisited by the same interviewer who had interviewed them at baseline. A tendency among operated cases to provide answers that would "please" the interviewers by overstating satisfaction with health-related quality of life therefore cannot be ruled out.

Conclusion

Cataract extraction in patients with glaucoma results in a significant improvement in vision. This improvement can be appreciated irrespective of the type of glaucoma and category of cataract. Along with vision, there is also a significant deepening of the AC, with a simultaneous reduction in the IOP among cohorts with open angle glaucoma, while angle closure group benefitted with a reduction in the number of anti-glaucoma medications. Cataract extraction also brings significant improvement in the quality of life when the cataract is denser or when it is of the posterior sub-capsular variety.

Cataract extraction results in significant improvement in the mean deviation during visual field analysis, an index of diffuse depression of the visual field. The PSD, an index of localized depression, did not change significantly. Studies on this index have been conflicting. Further studies are needed to confirm this issue.

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