DOI: https://doi.org/10.4038/jcosl.v30i2.98

Research article

Clinical outcome of combined phaco-trabeculectomy surgery in patients with coexisting cataract and glaucoma

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The Journal of the College of Ophthalmologists of Sri Lanka 2024; 30: 60-72

Abstract

Purpose: *To assess the relative effectiveness of combined phaco-trabeculectomy procedure in reducing intraocular pressure (IOP) and number of anti-glaucoma medications compared to phacoemulsification alone.*

Design and Methods: *94 eyes with open angle glaucoma and comorbid cataract that had combined phaco-trabeculectomy (combined group) or phacoemulsification alone (phaco-only) between 1st January 2018 and 31st December 2019 at Wrexham Maelor Hospital, United Kingdom were analysed retrospectively. Post-operative IOP, number of medications, visual acuity, complications and success rate were evaluated and compared.*

Results: *The reduction in mean IOP and number of anti-glaucoma medications were statistically significant in both groups at 6 months (P≤0.001), while the combined group showed a significantly higher reduction than that of the phaco-only group (P<0.001). The improvement of visual acuity at 6 months was significant in both groups (P< 0.001), while there was no significant difference in visual gain between the two groups (P=0.513). Post-operative complications of hyphaema, ocular hypotony, choroidal detachment and IOP spike were noted in 4(8.7%), 9(19.56%), 5 (10.87%) and 3(6.52%) eyes respectively in the combined group. Treatment failure was noted in 6 eyes (13.0%) in the combined group and 18 eyes (37.5%) in the phaco-only group. The combined group had a significantly higher treatment success than that of phacoemulsification alone (P<0.001).*

Conclusion: *Combined phaco-trabeculectomy procedure is superior to phacoemulsification alone in reducing IOP and medication dependency in patients with open angle glaucoma and coexisting cataract. However, phacoemulsification alone is a surgical option worth considering in certain groups of patients. Increased pre-operative number of medications and vertical cup-to-disk ratio (VCDR) are the risk factors for surgical failure.*

Introduction

Glaucoma is a progressive optic neuropathy characterised by accelerated degeneration of retinal ganglion cells and their axons. Visual field loss in glaucoma is irreversible and results in blindness in more advanced stages[1,2]. Blindness due to glaucoma remains as the leading cause of irreversible blindness worldwide[3]. Globally it has been estimated that in 2020 there is 79.6 million people with glaucoma, and of this 47% is comprised of Asians. Meanwhile, the estimated blindness from primary glaucoma is 11.1 million among the global population in 2020[4]. The magnitude of population with glaucoma is expected to increase to 111.8 million people by the year 2040[5].

Intraocular pressure (IOP) plays a major role in development and progression of glaucoma and remains as the only modifiable factor at present. Lowering the intraocular pressure is the only treatment option to slow the progression of glaucoma and also to prevent the development of glaucoma in patients with high IOP[6,7]. There are various methods available at present to achieve the target IOP including topical medications, selective laser trabeculoplasty, and glaucoma surgery. Topical medications are the first-line treatment. Glaucoma surgery is considered if medical treatment has failed or not well tolerated.

Cataract is the major cause of treatable blindness worldwide[3]. The ultimate treatment for cataract is the surgical removal of the cataractous lens and replacement with an implant.

While cataract and glaucoma remain as the leading causes of avoidable blindness and vision impairment, coexistence of both cataract and glaucoma in the elderly population is unavoidable. The social and economic impact due to the coexistence of cataract and glaucoma

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is anticipated to rise globally as the world's population continues to age. It affects the performance of various daily activities such as reading and driving and thereby the quality of life in these patients[3,8,9,10].

Blindness and vision impairment over the age of 50 years have been dramatically increased at present due to the growth and ageing of the world's population. The prevalence of global blindness has been estimated as 38.5 million people in 2020 and 114.6 million people by 2050[3,8]. Therefore, eliminating the burden of unnecessary blindness and vision impairment has become of utmost importance.

The pressure lowering effect and reducing drug dependency of phacoemulsification as a solo procedure in patients with glaucoma have been shown in literature. Aging crystalline lens plays an important role in intraocular pressure in patients with glaucoma. Lens extraction alone can reduce intraocular pressure by widening the drainage angle[11,12,13,14].

Trabeculectomy is one of the most effective and commonly performed surgical procedure for medically uncontrolled glaucoma[15]. However, cataract progression is accelerated after trabeculectomy demanding a second surgical procedure in future[16]. Performing cataract surgery in eyes with functioning filtering bleb may lead to bleb failure, compromising the IOP control[17]. On the contrary, performing trabeculectomy after phacoemulsification may reduce the success rate of the procedure[18].

Surgical techniques of both glaucoma and cataract extraction have been evolved and refined over the last few decades. Evolution of phacoemulsification in cataract surgery has led to significantly lower postoperative inflammation and less trauma leading to less fibrosis and peripheral anterior synechiae formation[19,20]. Therefore, performing combined cataract and glaucoma surgery in one setting is becoming increasingly popular, to address these two problems simultaneously[21,22].

Published literature has shown the effectiveness of combined phaco-trabeculectomy over phacoemulsification alone[23,24]. Some studies demonstrate non inferiority of phaco-trabeculectomy surgery in comparison to other combined cataract and novel glaucoma filtration procedures[22,25]. Meanwhile, some studies reported limited success with high rate of complications in phaco-trabeculectomy compared to trabeculectomy alone[26,27].

Jung et al. 2014[23] conducted a retrospective comparative study on the IOP control after trabeculectomy, phaco-trabeculectomy and phacoemulsification in a cohort of 153 patients with primary open angle glaucoma. Fifty-one patients were included in each group. Preoperative IOP was significantly higher in the phaco-trabeculectomy group than phaco-only group (P<0.001). The study demonstrated a significant reduction of IOP from baseline for the combined group (P=0.003) compared to the phaco-only group at 6 months follow up (P=0.111). There was a significant reduction in IOP-lowering medications from baseline in all three groups (P=0.001). Meanwhile, post-operative visual acuity was significantly improved in both groups after cataract extraction.

Liaska et al. 2014[28] conducted a prospective randomized clinical study on safety and efficacy of phaco-trabeculectomy surgery compared to phaco-emulsification alone in patients with open angle glaucoma and visually significant cataract. Sixty patients with advanced glaucoma who were controlled medically (IOP less than 22 mmHg) were randomly allocated: 29 and 31 patients into the combined phaco-trabeculectomy and phacoemulsification groups respectively. Patients were followed up for a period of two years. The study demonstrated a 1.7 mmHg reduction in IOP and 0.6 reduction in number of IOP-lowering medications in the combined group compared to phaco-only group while there was no difference in the improvement of visual acuity between the two groups.

Armstrong et al. 2017[29] conducted a meta-analysis on the effect of phacoemulsification alone on postoperative IOP and anti-glaucoma medications in patients with coexistent cataract and primary open angle glaucoma (POAG) after searching on multiple databases. Thirty-two studies with 1826 patients were included in the analysis. It showed a 15% reduction of IOP from baseline after 2 years and the effect was sustained at 9% at the end of 3 years. A mean reduction of 0.57, 0.47, 0.38 and 0.16 anti-glaucoma medication was demonstrated at 6 months, 1 year, 2 year and 3 year respectively. Meanwhile, a subgroup analysis showed a greater IOP reduction effect when pre-operative IOP was higher. Certain populations appear to experience much greater reductions in IOP than others. Therefore, authors recommended future studies to identify these high responding patients.

Shingleton et al. 2006[30] presented three- and five-year results of intraocular pressure changes and anti-glaucoma medication requirement after phaco-emulsification in patients with open angle glaucoma, glaucoma suspects, and those with no glaucoma. The study reported a small but statistically significant reduction of IOP from baseline which was sustained at 3 years and 5 years of follow up; 1.4 ± 3.3 mmHg (P=0.0025) and 1.8 ± 3.5 mmHg (P=0.005) respectively

in patients with open angle glaucoma. The study concluded that phacoemulsification alone can be considered as an appropriate surgical procedure for intraocular pressure control in certain patients depending on the severity of glaucoma.

The decision among performing cataract surgery alone versus glaucoma surgery alone versus combined procedure is complex and treatment of either condition can influence the other. On the contrary, it is difficult to make a credible conclusion on the best surgical procedure as literature remains controversial. In the background of uncertainty, the decision making based on clinical experience and the surgical technique with which the surgeon is familiar has become the norm.

No treatment method is proven to be gold standard and the ideal treatment strategy for this group of patients is yet to be further explored. Although combination of cataract surgery with various modern glaucoma outflow procedures have been introduced, trabeculectomy remains as the most cost-effective and technically less challenging procedure[20,23]. Therefore, assessing the safety and efficacy of combined phaco-trabeculectomy in real world situations will help ophthalmologists to determine the best treatment option for their patients.

Study design

The primary objective was to evaluate the effectiveness in reducing IOP and number of anti-glaucoma medications of combined phaco-trabeculectomy procedure in comparison to phacoemulsification alone in patients with coexisting cataract and glaucoma.

Secondary objectives were to assess the safety of phaco-trabeculectomy surgery by evaluating the post-operative complications, to determine the factors affecting clinical outcome.

A retrospective observational analysis was conducted with 6 months follow-up on all the patients with coexistent cataract and open angle glaucoma who had uncomplicated phacoemulsification alone or combined phaco-trabeculectomy between 1st January 2018 and 31st December 2019.

Patients with a history of previous intraocular surgery or procedure involving the conjunctiva, previous ocular trauma, angle closure glaucoma or neovascular glaucoma, existing macular pathology or patients with dementia or mental disability who are unable to complete visual acuity chart were excluded.

Thirty-seven patients (46 eyes) had phaco-trabeculectomy during the period of 1st January 2018 to 31st December 2019. Forty-eight (48 eyes) glaucoma patients who had phacoemulsification alone under the same surgeons over the same period of time were selected for comparison.

All procedures had been performed by two experienced surgeons in the department. All phaco-trabeculectomy were performed under sub-tenon anaesthesia while, phacoemulsification was performed under topical or sub-tenon anaesthesia.

The procedure of phaco-trabeculectomy in brief is as follows: Fornix-based conjunctival flap was fashioned superiorly. Partial thickness scleral flap was dissected into clear cornea. Standard phacoemulsification and IOL implantation were completed before sclerostomy. Viscoelastic substance was removed from the anterior chamber and acetylcholine was injected followed by peripheral iridectomy. Removal of trabecular section was performed using a Kelly punch. Corneal incisions were secured with stromal hydration without suturing. The scleral flap and conjunctiva were closed with 10-0 nylon sutures. Subconjunctival antibiotic and steroid injections were administered and a drop of atropine 1% was instilled at the end of the surgery. All patients received a combination of antibiotic and steroid drops 6 hourly for at least 2 weeks and reduced within 4 to 6 weeks depending on the clinical response. All IOP-lowering medications were discontinued to the eyes had phaco-trabeculectomy. Some IOP-lowering medications were stopped in some eyes had phacoemulsification alone depending on the severity of glaucoma.

Statistical analysis

All statistical analysis was performed using the Statistical Package for the Social Sciences version 17.0 (SPSS Inc, Chicago, IL). The mean and the standard deviation were the descriptive statistics used to summarize the continuous variables. The Independent sample t-test and paired sample t-test were used to compare continuous variables and Chi-square test was used to compare categorical variables. Multinomial logistic regression analysis was carried out to identify the factors affecting the treatment outcome of the surgical procedure. A p value <0.05 was taken as statistically significant.

Results

The combined phaco-trabeculectomy group comprised 46 eyes of 37 patients and the phaco-only group included 48 eyes of 48 patients. The mean age was 81.78 ± 6.17 years (range, 70-93) in the combined group and 82.58 ± 8.09 years (range, 65-100) in the phaco-only group. There was no significant difference in mean

age between the two groups (P=0.619). The age distribution of the two groups is shown in Figure 1 and Figure 2.

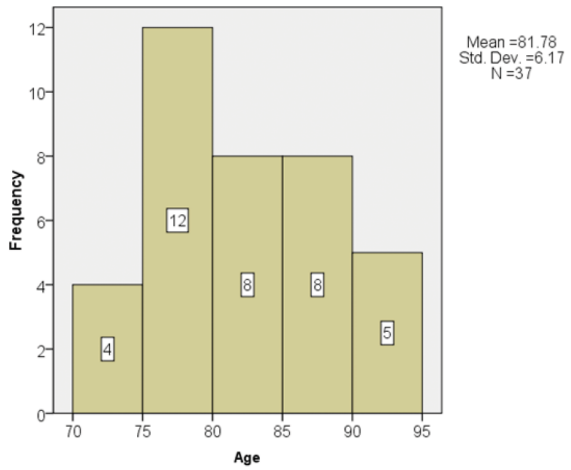

Figure 1. *Age distribution of the combined group.*

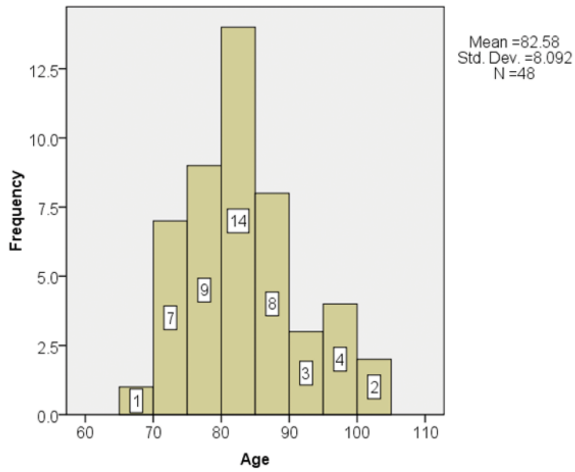

Figure 2. *Age distribution of the phaco-only group.*

The gender distribution of the studied population is illustrated in Figure 3 and shows more females than males in the combined group and vice versa in the phaco-only group.

POAG was the most common type of glaucoma seen in the studied population followed by Ocular hypertension (OHT) or Normal Tension Glaucoma (NTG). Pseudoexfoliation (PXF) glaucoma was less commonly seen and found in less than 5% of the eyes (Figure 4, 5).

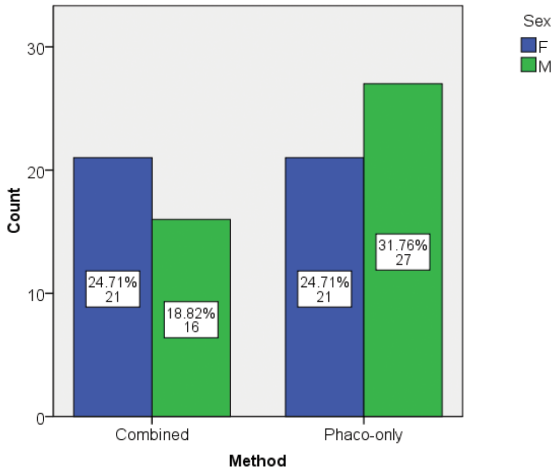

Figure 3. *Gender distribution between the two groups.*

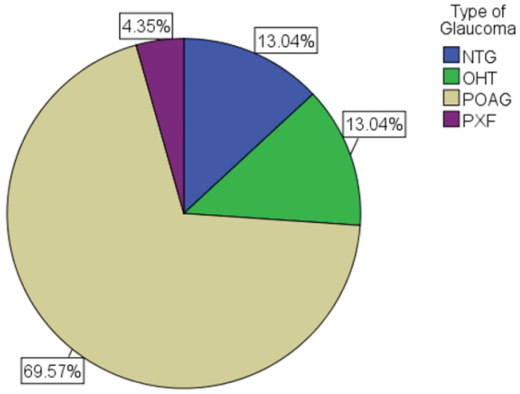

Figure 4. *Distribution of type of glaucoma in the combined group.*

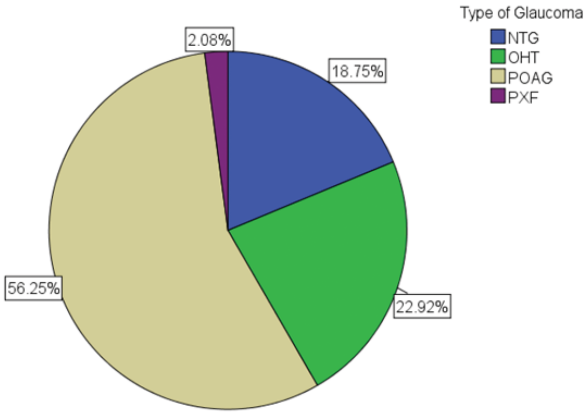

Figure 5. *Distribution of type of glaucoma in the phaco-only group.*

The patient demographics and pre-operative characteristics of the two groups are compared in Table 1. There was no statistically significant difference in the distribution of gender (P=0.234), ocular laterality (P=0.702) and the type of glaucoma (P=0.426) between the two groups pre-operatively.

However, there was a significant difference in the distribution of baseline ocular characteristics between the two groups. The pre-operative mean IOP was 21.7 ± 4.34 mmHg (range, 12-32 mmHg) in the phaco-trabeculectomy group and 17.71 ± 3.46 mmHg (range, 10-26 mmHg) in the phacoemulsification group.

Table 1. Demographic and pre-operative characteristics

Parameter	*Combined Group*	*Phaco-only Group*	*P Value*
No. of eyes	46	48	-
No. of patients	37	48	
Age (years)			
Mean age ± SD	81.78 ± 6.17	82.58 ± 8.09	0.619
Range	70-93	65-100	
Gender, n (%)			
Female	21 (56.76)	21 (43.75)	0.234†
Male	16 (43.24)	27 (56.25)	
No. of right eyes, n (%)	26 (56.52)	29 (60.42)	
No. of left eyes, n (%)	20 (43.48)	19 (39.58)	0.702†
Type of glaucoma, n (%)			
POAG	32 (69.57)	27 (56.25)	
NTG	6 (13.04)	9 (18.75)	
OHT	6 (13.04)	11 (22.92)	0.426†
PXF	2 (4.35)	1 (2.08)	
VCDR			
Mean ± SD	0.73 ± 0.17	0.65 ± 0.18	0.023
Range	0.3-0.95	0.3-0.95	
IOP (mmHg)			
Mean ± SD	21.7 ± 4.34	17.71 ± 3.46	< 0.001
Visual acuity (logMAR)			
Mean ± SD	0.27 ± 0.17	0.25 ± 0.15	0.439
Number of medications			
Mean ± SD	2.54 ± 0.81	1.35 ± 0.60	< 0.001
Surgeon, n (%)			
A	27 (58.7)	29 (60.42)	0.865†
B	19 (41.3)	19 (39.58)	

†Chi-square test

This difference was statistically significant (P<0.001). Patients in the phaco-trabeculectomy group were on significantly higher number of anti-glaucoma medications pre-operatively compared to the phaco-emulsification group (P<0.001). The combined group had a significantly higher Vertical Cup:Disc Ratio (VCDR) than the phaco-only group (P=0.023).

There was no significant difference in pre-operative mean visual acuity between the two groups (P=0.439). The number of patients operated by the two surgeons were evenly distributed between the two groups (P=0.865).

Pre-and post-operative IOP profiles of the 2 groups are shown in the Table 2. Post-operative characteristics of the two groups are compared in the Table 5.

The combined group had a significantly higher baseline IOP than the phaco-only group (P<0.001).

In the combined group, post-operative mean IOP was decreased from baseline of 21.7 ± 4.34 mmHg to 14.7 ± 4.75 mmHg at one month and to 14.83 ± 3.62 mmHg at 6 months follow-up. The amount of IOP reduction was 7.00 ± 5.79 mmHg (30.27% proportional reduction) and 6.87 ± 5.03 mmHg (29.66%) at one month and 6 months respectively. This reduction was statistically significant at both visits compared to baseline (P<0.001).

In the phacoemulsification group, mean post-operative IOP was 17.38 ± 6.23 mmHg at 1 month and 15.77 ± 2.96 mmHg at 6 months. This showed a reduction of 0.33 ± 5.61 mmHg (1.11%) and 1.94 ± 3.70 mmHg (8.51%) from baseline at one month and 6 months respectively. The IOP change at 1 month was not statistically significant (P=0.682), whereas the reduction at 6 months was significant (P=0.001).

There was a statistically significant difference in the reduction of mean IOP between the two groups. The combined group had a significantly higher reduction at both 1 month and 6 months follow-up compared to phacoemulsification alone (P< 0.001). The proportional reduction was 29.66% in the combined group and 8.51% in the phaco-only group.

Table 3 compares the pre- and post-operative mean number of anti-glaucoma medications in the 2 groups. The combined group was on significantly higher number of medications pre-operatively than the phaco-only group (P<0.001).

The mean number of anti-glaucoma medications at 6 months was 0.35 ± 0.82 in the combined group and 0.83 ± 0.86 in the phaco-only group. This difference was statistically significant (P=0.006). Therefore, the phaco-only group required a higher number of medications compared to the combined group at the end of 6 months.

However, the both groups showed a significant reduction in required number of medications compared to the baseline at the final visit (P<0.001). The need for medication was reduced by an average of 2.2 ± 0.93 (88.59%) in the combined group and 0.52 ± 0.74 (40.63%) in the phaco-only group. This difference also was statistically significant (P<0.001). Therefore, the combined surgery showed a significantly greater reduction in number of medications than that of phacoemulsification alone (P<0.001). At 6 months follow up, 8 (17.39%) eyes in the combined group and 28 (58.33%) eyes in the phaco-only group required IOP lowering medications.

Table 2. Change in intraocular pressure (mmHg)

Variables	*Combined Group*	*Phaco-only Group*
Pre-operative IOP		
Mean ± SD	21.7 ± 4.34	17.71 ± 3.46
IOP at 1month		
Mean ± SD	14.7 ± 4.75	17.38 ± 6.23
IOP at 6 months		
Mean ± SD	14.83 ± 3.62	15.77 ± 2.96
P value		
At 1 month	< 0.001	0.682
At 6 months	< 0.001	0.001

Table 3. Change in No. of anti-glaucoma medications

Variables	*Combined Group*	*Phaco-only Group*	*P value*[a]
Preoperative No. of medications Mean ± SD	2.54 ± 0.81	1.35 ± 0.60	<0.001
No. of medications at 6 months Mean ± SD	0.35 ± 0.82	0.83 ± 0.86	0.006
P value[b]	<0.001	<0.001	

[a] Independent t-test for combined group and phaco-only group

[b] Paired t-test for baseline and post-operative values

Table 4. Change in visual acuity (logMAR)

Variables	*Combined Group*	*Phaco-only Group*
Pre-operative VA Mean ± SD	0.27 ± 0.17	0.25 ± 0.15
Post-operative VA at 1 month Mean ± SD	0.20 ± 0.23	0.12 ± 0.03
Post-operative VA at 6 months Mean ± SD	0.07 ± 0.14	0.07 ± 0.13
P value		
At 1 month	0.063	<0.001
At 6 months	<0.001	<0.001

Table 5. Group comparison of the post-operative characteristics

Parameter	*Combined Group*	*Phaco-only Group*	*P Value*
Mean IOP reduction at 1 month			
(mmHg) ± SD	7.00 ± 5.79	0.33 ± 5.61`	<0.001
(%) ± SD	30.27 ± 23.23	1.11 ± 30.67	<0.001
Mean IOP reduction at 6 months			
(mmHg) ± SD	6.87 ± 5.03	1.94 ± 3.70	<0.001
(%) ± SD	29.66 ± 18.95	8.51 ± 22.16	<0.001
Mean VA change at 1 month (logMAR) ± SD	0.07 ± 0.26	0.12 ± 0.14	0.249
Mean VA change at 6 months (logMAR) ± SD	0.20 ± 0.18	0.18 ± 0.15	0.513
Reduction in No. of medications			
Mean ± SD	2.2 ± 0.93	0.52 ± 0.74	<0.001
% ± SD	88.59 ± 27.18	40.63 ± 56.17	<0.001

There was no significant difference in baseline visual acuity between the two groups (P=0.439). Visual gain at 1 month in the combined group was not statistically significant (P=0.063), while the improvement at 6 months was significant (P<0.001). However, the phaco-only group showed a statistically significant improvement in visual acuity at both 1 month and 6 months follow up (P<0.001). There was no significant difference in the improvement of visual acuity between the two groups at the end of 6 months (P=0.513).

In the combined group, 38 (82.6%) eyes met the criteria for complete success, while treatment failure was noted in 6 eyes (13.0%). However, the results are highly different with the phaco-only group that only 20(41.7%) eyes met the criteria for complete success, while treatment failure was noted in 18 eyes (37.5%). Meanwhile, 2 (4.3%) eyes and 10 (20.8%) eyes met the criteria for qualified success in the combined group and phaco-only group respectively. Table 6 summarises the treatment outcomes of the two groups.

To identify whether the treatment outcome is independent of the method of surgery, Pearson Chi-Square test was carried out. The results showed that there was a significant difference in treatment outcome between the two groups (P<0.001). Therefore, it can be concluded that the combined group had a higher treatment success and lower treatment failure rate than that of phacoemulsification alone.

Multinomial logistic regression analysis was carried out to identify the factors affecting the treatment outcomes of the surgical procedures. Treatment outcome was considered as the dependent variable and pre-operative IOP, number of pre-operative drops, VCDR, method of surgery, type of glaucoma and surgeon factor were considered as the independent variables.

The results showed that there was a significant association of the surgical method (P<0.001), number of pre-operative medications (P=0.023) and VCDR (P=0.014) with the treatment outcomes, while the baseline IOP (P=0.409), type of glaucoma (P>0.05) and surgeon factor (P=0.748) did not show any significant relationship with the treatment outcomes.

Pre-operative medications and VCDR showed an inverse relationship with the complete success rate. For each unit increase in VCDR, the odds of being the surgery a complete success rather than a failure was decreased by 99.9% (odds ratio 0.001, 95% CI: 2.16×10-6-0.228). Meanwhile, for increase in each number of antiglaucoma medications the odds of the surgery being a complete success rather than failure was reduced by 72.7% (odds ratio 0.273, 95% CI: 0.089-0.839). Therefore, increase in VCDR and number of baseline medications make the surgery to be less successful.

The combined surgery showed 147.5 times higher odds (odds ratio 148.495, 95% CI: 9.710 - 2270.964) of being complete success rather than a failure compared to phacoemulsification alone. Meanwhile, there were no independent variables found that show a statistically significant relationship to distinguish qualified success from failure.

The complications occurred and the interventions required after combined phaco-trabeculectomy surgery are summarized in the Table 7. Complications occurring within the first month of the surgery were considered as early post-operative complications.

Table 6. Treatment outcomes of the two groups

		Treatment Outcome			*Total*
		C	*F*	*Q*	
Surgery combined	Count	38	6	2	46
	% within method	82.6%	13.0%	4.3%	100.0%
Phaco-only	Count	20	18	10	48
	% within method	41.7%	37.5%	20.8%	100.0%
Total	Count	58	24	12	94
	% within method	61.7%	25.5%	12.8%	100.0%

C = Complete success, Q = Qualified success, F = Failure

Table 7. Summary of postoperative complications and interventions in the combined group

Complications and interventions	*Eyes (n, %)*
Hyphaema	4 (8.69%)
Hypotony	9 (19.56%)
Transient choroidal effusion	4 (8.69%)
Prolong choroidal effusion	1 (2.17%)
IOP spike	3 (6.52%)
Endophthalmitis	0 (0)
Blebitis	0 (0)
Laser suturelysis	5 (10.87%)
Bleb massaging	8 (17.39%)

The incidence of hyphaema was in 4 (8.69%) eyes and all resolved spontaneously within 2 weeks. Ocular hypotony was noted in 9 (19.56%) eyes. Five (10.87%) eyes developed choroidal detachment; 4 cases were transient and only one developed prolong choroidal detachment which settled by the end of 6 months. Post-operative IOP spike was noted in only 3 cases (6.52%). IOP rise of ≥25 mmHg on the first post-operative day was considered as IOP spike.

Post-operative interventions such as bleb massaging, and argon laser suturelysis were required in 8 and 5 eyes respectively. None of the eyes required reoperation within the period of 6 months. There were no cases of bleb leakage, blebitis or endophthalmitis.

Discussion

There was no statistically significant difference in demographic characteristics such as age, gender, ocular laterality or type of glaucoma between the 2 groups (P=0.619, P=0.234, P=0.702, P=0.426 respectively). Patients in the combined group had significantly higher baseline IOP, VCDR and number of anti-glaucoma medications compared to the phaco-only group (P<0.001, P=0.023, P<0.001 respectively). Therefore, the combined group had more advanced glaucoma than that of phaco-only group.

The wash out period of anti-glaucoma medications can be extended for 4 weeks after discontinuation of treatment[31]. Therefore, IOP measurement at 1 month was considered for early post-operative outcome analysis. The IOP reduction at 1 month in the phaco-only group was not statistically significant (P=0.682), whereas the reduction at 6 months was significant (P=0.001). This suggests that post-operative inflammation may have had a significant impact on the already compromised trabecular meshwork in open angle glaucoma after phacoemulsification. Steroid-induced raised IOP due to presence of steroid responders could be another influential factor on the high IOP reading at one month[32]. In contrast, the combined group showed a better IOP control at both early and late postoperative period (P<0.001). Therefore, further damage due to post-operative high IOP on already advanced glaucomatous optic nerve head can be avoided with the combined procedure.

IOP reduction of the present study is consistent with previous studies done on the subject. Kang et al.[33] noted a significantly higher pre-operative IOP in the combined group compared to the phaco-only group (P<0.001), while there was a significant reduction of IOP from baseline at 12 months in the both combined and phaco-only groups (P<0.001). The present study demonstrated a significantly greater reduction in IOP in the combined group compared to the phaco-only group (P<0.001). Jung et al.[23] presented data of a retrospective comparative study on IOP control effect of trabeculectomy, phaco-trabeculectomy and phacoemulsification in patients with primary open angle glaucoma. The study had almost similar number of cases and a similar period of follow-up of 6 months as per the current study. The study demonstrated a 20.8 % reduction of IOP from baseline for the combined group and 6.5% of reduction for the phaco-only group. This is comparable to the results of the present study of 29.66% and 8.51% reduction in IOP in the combined group and the phaco-only group respectively.

Jung et al.[23] also reported a 3.4 ± 1.1 (P<0.001) and 0.6 ± 1.2 (P=0.001) significant reduction in mean number of anti-glaucoma medications in the combined group and the phaco-only group respectively. Similarly, the present study demonstrated 2.2 ± 0.93 (88.59%) reduction in IOP-lowering medication in the combined group and 0.52 ± 0.74 (40.63%) reduction in the phaco-only group.

In the present work, both the groups showed a significant reduction in IOP and required number of medications at 6 months compared to the baseline (P<0.001). However, these reductions were significantly greater in the combined group (P<0.001). Therefore, it can be concluded that the combined group is more effective in reducing IOP and medication dependency than that of phacoemulsification alone in patients with open angle glaucoma and coexisting cataract.

The study showed a significant improvement in visual acuity at one month in the phaco-only group (P< 0.001) but not for the combined group (P=0.063). However, the visual gain at 6 months was significant in both groups (P<0.001). This indicates a delayed visual recovery in the combined group than that of phaco-emulsification alone. However, there was no group difference in the final visual acuity at 6 months (P=0.513). Therefore, despite the delay in visual rehabilitation, the combined procedure shows a similar visual gain as per the uncomplicated phaco-emulsification alone, while avoiding a need for a second surgical procedure in future. Furthermore, the financial burden and risk of complications associated with a second surgical procedure is eliminated with the combined surgery.

Even one millimeter of mercury reduction in IOP can decrease the progression of optic nerve damage in open angle glaucoma[34]. Meanwhile, long term exposure to IOP-lowering medications and usage of multiple anti-glaucoma medications pre-operatively have been identified as risk factors for surgical failure in patients with glaucoma[35,36].

In the present study, the phaco-only group had less severe glaucoma at baseline and demonstrated 1.94 ± 3.70 mmHg (8.51%) reduction of IOP and 0.52 ± 0.74 (40.63%) reduction of number of medications at 6 months. Both these reductions were at a significant level (P<0.001). Therefore, the results of this study suggest that uncomplicated phacoemulsification alone can reduce the need of multiple medications in patients with less severe open angle glaucoma, while reducing the IOP to a lesser, but significant degree. Therefore, phacoemulsification alone may be sufficient to delay the progression of optic nerve damage and could be considered as a surgical option for certain patients with mild open angle glaucoma and coexisting cataract.

Complications and adverse events of the combined procedure in the current study are comparable to previous reports. Liaska et al.[28] and Jung et al.[23] reported 17.24% ocular hypotony with 6.89% of choroidal detachment and 23.5% cases of ocular hypotony with 3.92% of choroidal detachment respectively. This is comparable to 19.56% of ocular hypotony and 10.87% of choroidal detachment in the present study. Although a slightly higher rate of choroidal detachment was noted in the current study, most of these cases were transient and resolved spontaneously. Only one patient had persistent choroidal detachment which lasted for 3 months and then settled without affecting the final visual acuity. Conversely Jung et al.[23] reported a high rate of prolong hypotony of 9.8% persisting after 1 month. Although the number of patients and define criteria of complications of Jung et al.[23] is almost similar to the present study, the slight variation in complications may be due to differences in surgical technique and racial differences between the two populations.

The present study had a relatively low rate of IOP spikes of 6.52% on the immediate post-operative day compared to 24.13% and 9.8% by Liaska et al.[28] and Jung et al.[23] respectively. Post-operative hyphaema was seen in 8.69% cases and resolved spontaneously within 2 weeks. Jung et al.[23] reported 0% cases of hyphaema and 9.8% cases of bleb leakage.

Eight eyes required digital massaging and 5 eyes underwent argon laser suture lysis at early post-operative period to maintain the functional status of the bleb. Severe complications such as persistent hypotony, bleb leakage, or infection were not reported in the studied population. Only one eye with advanced glaucoma had slight worsening of visual acuity post-operatively; loss of one-line vision on the Snellen's chart. Over filtering bleb and shallow anterior chamber were also noted in early post-operative period in the same eye. Presence of pale neuro-retinal rim and post-operative hypotony have been described as risk factors for post-operative visual loss in patients with advanced glaucoma after trabeculectomy[37].

However, most of the complications were transient and self-limiting, and there were no major post-surgical interventions required in the studied population. Trabeculectomy is known to be associated with serious post-operative complications[37,38,39] and the risk of complications are expected to higher once it is combined with another procedure. However, the results of this study suggest that combined phaco-trabeculectomy surgery is a safe procedure which can be performed with promising results, in experienced hands.

Only few reports on the subject had analysed the treatment success versus failure. Treatment outcome of the present study was divided into three categories as complete success, qualified success and treatment failure depending on the post-operative IOP and required number of medications. There was a significantly higher treatment failure in the phacoemulsification group compared to the combined group (P<0.001). Similar results have been shown by Jung et al.[23]. However, the direct comparison of treatment outcome between the present study and other reports on the subject is difficult due to slight variations in outcome criteria.

Demographic characteristics such as age, sex and ocular laterality were considered as potential confounding variables and evaluated. The results did not

show any significant association with treatment outcome (P>0.05).

The study demonstrated a significant, but opposite relationship between pre-operative anti-glaucoma medications (P=0.023) or VCDR (P=0.014) and the treatment outcome; higher the number of baseline medications or VCDR, lesser the surgery to be complete success. Therefore, this suggests that more advanced the glaucoma, less the chance of successful surgery. Therefore, considering surgical interventions earlier in the course of disease progression is warranted. Unexpected vision loss after filtering procedures in patients with advanced glaucoma can also be avoided with early intervention[37,39].

Meanwhile, the published literature has shown that the reduction of IOP after phacoemulsification is proportional to the pre-operative IOP level: higher the pre-surgical IOP, greater the reduction post-operatively[11,13,29]. However, the present study did not show any correlation between the baseline IOP and the treatment outcome. Similarly, type of glaucoma and surgeon factor did not show any significant correlation with the complete success rate (P>0.05), and therefore were not deciding factors for treatment outcome.

Limitations

A major drawback of the present study was inability to randomize and therefore selection and observer bias were unavoidable. Phaco-trabeculectomy is not a commonly performed surgical procedure in ophthalmic practice. Therefore, obtaining an adequate sample which is sufficient enough to carry out statistical analysis was a difficult task. As it was a retrospective study, randomization could not be carried out.

Indication for combined phaco-trabeculectomy or phacoemulsification alone depends on the severity of glaucoma and the target IOP. Patients with more advanced and uncontrolled glaucoma naturally get selected for Phaco-trabeculectomy procedure. Therefore, there is an element of selection bias.

However, the main intention of the study was to evaluate the surgical outcome of the combined phaco-trabeculectomy procedure in real clinical practice. Hence, lack of randomization and the baseline difference between the two treatment groups should be kept in mind when interpreting the results of the study.

The study is limited by the sample size. The group comparison for relationship between type of glaucoma and treatment outcome, could not be interpreted due inadequate number of cases in each outcome category. Another limitation of the study is the relatively short period of follow-up. Therefore, the long-term outcome and success rates of the two surgical procedures are unknown. Progression of visual field defects could not be analyzed due to the short period of follow up.

Ethnicity and race of the studied population has not been considered. There could be some variation in the treatment outcome among certain populations.

Only the visual acuity was considered as a measurement of visual outcome. Changes in visual field parameters and the vision related quality improvement have not been assessed.

Some IOP-lowering medications were stopped only in some eyes that had phacoemulsification alone depending on the severity of glaucoma. Surgeons were reluctant to withhold all the antiglaucoma medications in patients with extended optic nerve damage. Therefore, withholding of anti-glaucoma medications post-operatively was not uniform among the patients in the phaco-only group.

Conclusion and Recommendations

It can be concluded that the combined phaco-trabeculectomy procedure is superior to phaco-emulsification alone in reducing IOP and medication dependency in patients with open angle glaucoma and coexistent cataract.

Performing phacoemulsification alone is not an option for patients with advanced open angle glaucoma and coexisting cataract. However, early phaco-emulsification can be considered as a reasonable surgical option for certain patients based on the extent of optic nerve damage and the target IOP.

Increased number of pre-operative medications and higher VCDR are the risk factors for surgical failure. Meanwhile, pre-operative IOP and type of glaucoma were not the deciding factors for treatment outcome.

Further studies are warranted to determine the category of patients who responds to phacoemulsification alone. Prospective randomized controlled trials with large sample size is recommended to illustrate this problem better.

Place of study

Study carried out at Department of Ophthalmology, Wrexham Maelor Hospital, Betsi Cadwaladr University Health Board, Croesnewydd Road, Wrexham, United Kingdom. Presented earlier as MD thesis.

Ethical clearance

Audit registration No. 18/234: The data were managed in accordance with University Health Board guidance on data protection. No patient identifiable data were collected, and confidentiality of all data were ensured. All data collection was anonymous and was handled by the principle investigator only for the purpose of this research. Data were entered on a password protected computer.

Acknowledgement

Mr. Lakshan Aponsu, Senior Lecturer, Wayamba University of Sri Lanka his guidance and assistance on statistical analysis.

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