Original Article
Phacoemulsification combined with intraocular lens implantation alone or associated with vitreous aspiration in angle closure glaucoma with concomitant cataract

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Abstract: To observe curative effects of phacoemulsification combined with intraocular lens implantation alone or associated with vitreous aspiration in treating angle closure glaucoma (ACG) patients with concomitant cataract. A retrospective comparative analysis of 72 ACG patients (78 eyes) with concomitant cataract was conducted. Patients in group A underwent phacoemulsification combined with intraocular lens implantation alone, and patients in group B received phacoemulsification combined with intraocular lens implantation associated with vitreous aspiration, respectively. There were no statistical differences in pre-operative average visual acuity (VA), intraocular pressure (IOP), anterior chamber depth (ACD), angle opening distance (AOD) (all $P > 0.05$). Post-operative VA, IOP, ACD, AOD and the degree of angle opening were all improved in group A and group B as compared with pre-operative levels (all $P < 0.05$). But there was no obvious difference between group A and group B with respect to VA, IOP, ACD, AOD and the degree of angle opening post-operatively (all $P > 0.05$). There were incidence of transient high IOP, anterior chamber fibrin and corneal bedewing in both group A and group B post-operatively, with statistical difference between groups ($P < 0.05$). Phacoemulsification combined with intraocular lens implantation alone or associated with vitreous aspiration both resulted in substantial visual recovery, excellent IOP control, and decreased extent of synechial angle closure. Importantly, phacoemulsification combined with intraocular lens implantation would be more efficacious in lowering complication rates in ACG patients with concomitant cataract.

Keywords: Angle closure glaucoma, cataract, phacoemulsification, intraocular lens implantation

Introduction

Glaucoma is a kind of eye disease that is caused by the continuous increase of intraocular pressure (IOP), where the sustained high IOP can cause damage to the parts of the eyeball [1]. Angle closure glaucoma and open angle glaucoma are two major types commonly used for the classification of glaucoma [2]. Due to certain eye disease or systemic disease, the secondary glaucoma may contribute to serious damage to the normal aqueous humor cycling and raised IOP [3]. Secondary glaucoma can be divided into two types, which are closed or open-angle [4]. As a result of secondary glaucoma has been more serious primary disease, its treatment is becoming more complex than the primary glaucoma, so as to its prognosis [5]. With respect to angle closure glaucoma

(ACG), which is typically characterized by closure of the anterior chamber drainage angle, thereby blocking the outflow of aqueous humor, with resultant elevated IOP and the development of progressive irreversible optic neuropathy causing peripheral vision loss [6]. In patients with cataract, when ACG coexists with cataract, a clouding of the lens or opacity inside the eye leads to a decrease in vision and may even result in visual loss because opacification of the lens obstructs light from passing and being focused on the retina at the back of the eye [7-9]. Clinical exploration has proved that the underlying cause of secondary ACG may be attributed to the close of angle directly by local iris and angle factors due to the turbidity, swelling, and thickening of lens, or by acting to move the crystalline lens forward causing pupillary block (secondary pupillary block), leading to the

blockage of anterior aqueous flow, increased IOP as well as ocular morbidity that resulting in glaucoma [10]. Once diagnosed, this disease need to be timely treated, otherwise, it is a serious threat to the normal life of patients.

Currently, the clinical treatment of the disease is mainly surgical treatment [11, 12]. The standard initial management of ACG is lowering IOP medically, and these patients with secondary pupillary block will respond to laser peripheral iridotomy (LPI) traditionally, relieving pupil block, the predominant mechanism of ACG; however, long-term IOP control after LPI is poor [13]. In recent decades, accumulated evidences have reported the apparent IOP-lowering effect of cataract extraction alone by phacoemulsification [14]. Phacoemulsification cataract surgery is one option for the management of the patient with ACG and cataract, which is to remove the lens factor caused by the pupil-blocking and closed-angle and contribute to early visual rehabilitation, complication reduction, long-term reduction of post-operative IOP elevation and decrease the need for glaucoma medication [12, 15]. As for the management of secondary ACG patients with concomitant cataract, when the patients with acute exacerbation stage, corneal edema, corneal endothelial cell damage, the lens may further damage the corneal endothelial cells, there may be corneal endothelial loss, phacoemulsification cataract surgery and combine operation may therefore be better than the single surgery [16, 17].

In this study, to compare the efficacy in visual rehabilitation, IOP control, anterior chamber depth (ACD), angle opening distance (AOD), the degree of angle closure and surgical complications, phacoemulsification combined with intraocular lens implantation alone or associated with vitreous aspiration were applied in patients with medically controlled secondary ACG with concomitant cataract to evaluate curative effects of both surgeries.

Materials and methods

Ethics statement

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Due to the retrospective nature of the study, informed consent was waived.

Subjects

A total of 72 patients (78 eyes) with secondary ACG with concomitant cataract were randomly incorporated in the study from February, 2012 to August, 2015 in the First People's Hospital of Shunde, China. Of these patients, there were 24 males (24 eyes) and 48 females (54 eyes), with an age range of 46-82 years (mean age, 66.65 ± 6.36 years). Secondary ACG was defined as a glaucoma caused by other eye diseases resulting in angle closure, showed acute development process, rapid progression of the disease, often suffering from obvious eye pain, halos, obvious blurred vision, also accompanied by ipsilateral headache, even severe nausea and vomiting in severe cases, which mainly included intumescent cataract secondary ACG (26 eyes), secondary ACG due to traumatic intraocular (22 eyes), iridocyclitis with posterior synechia induced secondary ACG (14 eyes), and ciliary block glaucoma (10 eyes), respectively, in this study. According to the diagnostic criteria formulated by Chinese Medical Association Ophthalmology Branch Glaucoma Group, all included subjects were diagnosed with secondary ACG with concomitant cataract [18]. Inclusion criteria for the eligible patients were as follows: (1) slit-lamp examinations indicated the presence of shallow anterior chamber, iris swelling, crystal expansion and narrow angle; (2) presence of angle closure at different degrees by routine gonioscopy; (3) interrupted areas of peripheral anterior synechiae (goniosynechiae) in all patients, with angle closure ranging from II to IV, based on pre-operative gonioscopy; and (4) there were different degrees of opacity in the lens nucleus and cortex (II~IV grade) according to the LOCS classification. Patients, who had (1) open angle glaucoma; (2) retinal detachment and retinal hemorrhage; (3) history of anti-glaucoma surgery or other ophthalmologic surgeries; or (4) systemic diseases that might affect prognosis, such as poor glycemic control in diabetic patients, and serious cardiopulmonary disease accompanied by PACG, were excluded. The patients were divided into two groups: group A and group B. In group A, there were a total of 46 eyes (46/78, 58.97%) from 42 cases (male, n = 12, female, n = 30; mean age, 66.65 ± 6.36 years) who were previously received drug treatment showing a normal IOP. Meanwhile, in

Table 1. Pre-operative and post-operative VA in the two treatment groups

Group		Group A (46 eyes)	Group B (32 eyes)
Pre-operative	< 0.2	6	2
	0.2-0.5	26	16
	0.5-0.8	10	10
	0.8-1.0	3	4
	> 1.0	1	0
Post-operative	< 0.2	3	0
	0.2-0.5	14	7
	0.5-0.8	21	18
	0.8-1.0	6	6
	> 1.0	2	1

Group A, patients who were previously received drug treatment showing a normal IOP, treated with phacoemulsification combined with intraocular lens implantation; group B, patients with shallowing of the anterior chamber and high IOP following 3-5 days drugs treatment, treated with vitreous aspiration and followed by phacoemulsification combined with intraocular lens implantation. VA: visual acuity.

group B, there were 32 eyes (32/78, 41.03%) from 30 cases (male, n = 12, female, n = 18; mean age, 66.28 ± 6.36 years) with shallowing of the anterior chamber and high IOP following 3 to 5 days' drugs treatment received vitreous aspiration and followed by phacoemulsification combined with intraocular lens implantation. Statistical differences in gender or age were not apparent between group A and group B (all $P > 0.05$).

Surgical procedure

In group A, patients received phacoemulsification combined with intraocular lens implantation. Specifically, scleral tunnel incision (3.0 mm) was performed at 2.0 mm above the upper edge of the cornea after successful ocular anesthesia with the administration of 2.5 ml lidocaine (2%) and 2.5 ml bupivacaine. Then cataract extraction was performed using a standardized clear-corneal approach: viscoelastic agent was injected at the 3-o'clock position 360° circumferentially in the angles to deepen the anterior chamber for hydrodissection; and then phacoemulsification of the lens was carried out by using the cataract ultrasonic emulsification instrument (Bausch & Lomb Eyecare Co., Ltd., Beijing, China) to completely pump residual cortex. And then, in-the-bag implantation of a standard foldable intraocular lens (IOL) was performed after viscoelastic

reinjection. Detailed procedure regarding vitreous aspiration was as follows: under a retrobulbar anesthesia, the long-acting retrobulbar block is performed using a 23-gauge needle (2.5 mL). Vertical wall of the eyeball wall was punctured at 3.5-4.5 mm from the superior temporal, extending to the 12 mm in the eye, slow pumping suction amount of vitreous humor to normal intraocular pressure. Also, patients in group B underwent phacoemulsification combined with intraocular lens implantation with the same way utilized in group A. After wound closure, all patients in the two groups were routinely administrated with antibiotic for the prevention of infection, and all eyes were treated with anti-inflammatory Tobradex drops post-operatively.

Outcome measures

All patients were followed up for 6 month. Post-operative VA, ACD, IOP, the degree of angle closure, and complications were observed and recorded within the follow-up. ACD was defined as the vertical distance from the inner surface of the corneal anterior chamber to the anterior crystalline lens surface. AOD was expressed as the distance between 2 crossover points of the inner surface of the cornea and the anterior surface of the iris through a circle, whit scleral spur as the center of the circle and a radius of 500 μm. An average of three times measurements was obtained for the following statistical analyses IOP was measured using noncontact air-puff tonometry (CT-60 computerized tonometer, Topcon Ltd., Japan) by an experienced technician. Ultrasound biomicroscopy (UBM) laser profilometry was employed in the assessment of the degree of angle closure, ACD, and AOD.

Statistical analysis

SPSS 18.0 statistical software was used for data analysis. Measurement data were presented as mean ± standard deviation (x ± s), and the χ^2 test to compare enumeration data. The *t* test was applied to compare the data between groups. A $P < 0.05$ was considered as statistically significant.

Results

Comparison of VA

Pre-operatively, there was no statistically difference with respect to VA between groups

Table 2. Pre-operative and post-operative IOP in the two treatment groups (mmHg)

	Group A (46 eyes)	Group B (32 eyes)	t	P
Pre-operative	20.24 ± 1.72	24.24 ± 2.23	-8.923	< 0.001
7 days after surgery	14.21 ± 1.39*	14.04 ± 1.37*	0.518	0.606
4 weeks after surgery	14.20 ± 1.16*	14.03 ± 1.38*	0.592	0.556
12 weeks after surgery	13.72 ± 1.26*	13.98 ± 1.17*	-0.900	0.371
24 weeks after surgery	14.02 ± 1.34*	13.63 ± 1.43*	1.212	0.229

Group A, patients who were previously received drug treatment showing a normal IOP, treated with phacoemulsification combined with intraocular lens implantation; group B, patients with shallowing of the anterior chamber and high IOP following 3-5 days drugs treatment, treated with vitreous aspiration and followed by phacoemulsification combined with intraocular lens implantation; *, compared to pre-operative IOP, P < 0.05. IOP: intraocular pressure.

Table 3. Pre-operative and post-operative ACD and AOD in the two treatment groups (mm)

	Group A (46 eyes)	Group B (32 eyes)	t	P
ACD				
Pre-operative	1.86 ± 0.26	1.89 ± 0.22	-0.508	0.613
Post-operative	2.87 ± 0.24	2.88 ± 0.22	-0.191	0.849
t	-19.318	-18.023	-	-
P	< 0.001	< 0.001	-	-
AOD				
Pre-operative	0.11 ± 0.02	0.10 ± 0.02	1.637	0.106
Post-operative	0.26 ± 0.03	0.28 ± 0.03	1.981	0.051
t	-26.059	-26.789	-	-
P	< 0.001	< 0.001	-	-

Group A, patients who were previously received drug treatment showing a normal IOP, treated with phacoemulsification combined with intraocular lens implantation; group B, patients with shallowing of the anterior chamber and high IOP following 3-5 days drugs treatment, treated with vitreous aspiration and followed by phacoemulsification combined with intraocular lens implantation. ACD: anterior chamber depth; AOD: angle opening distance.

Post-operatively, the average IOP of included eyes were 14.04 (11.58~17.08) mmHg and 13.92 (11.68~16.88) mmHg in group A and group B, respectively. The comparison of IOP pre-operatively and post-operatively between groups was presented in **Table 2**. There was significantly difference regarding average IOP between groups pre-operatively ($P < 0.05$). Pre-operative and post-operative results comparison indicated that after corresponding surgical intervention, IOP showed an increased tendency in both groups than that of the value before surgery (all $P < 0.05$). But there was no statistical differences between group A and group B considering post-operative IOP (all $P > 0.05$).

ACD, AOD and the degree of angle closure

The pre- and post-operative ACD and AOD observation with UBM laser profilometry within the two treatment groups were summarized in **Table 3**. The incorporated 78 eyes were all showed shallow ACD pre-operatively, with a mean ACD of 1.88 ± 0.24 mm; and post-operatively, the mean ACD was 2.87 ± 0.23 mm, showing an obviously increased tendency. No statistically significant differences in ACD were observed in group A and group B pre-operatively, respectively (t = -0.508, $P = 0.613$). Post-operative ACD in all patients of group A and group B were higher than the pre-operative values (t = -19.318, $P < 0.001$; t = -18.023, $P < 0.001$; respectively).

After the surgery, the AOD was increased than that pre-operatively under the routine gonioscopy examination in both groups, similar trend was also detected in both groups when compared to values of AOD pre-operatively (all $P < 0.05$). In addition, there were no statistically significant differences among the two groups in terms of pre-operative or post-operative AOD

($χ^2$ = 3.040, $P = 0.571$). Post-operative VA in group A and group B both showed evident increased tendency as compared with the pre-operative levels, indicating statistical difference ($χ^2$ = 9.837, $P = 0.035$; $χ^2$ = 8.700, $P = 0.034$; respectively). However, there was no statistical differences exist between group A and group B in terms of post-operative VA ($χ^2$ = 3.219, $P = 0.529$) (**Table 1**).

Comparison of IOP

The average IOP of those included 78 eyes was 29.81 (range: 11.25-55.94) mmHg pre-operatively; and after drugs treatment pre-operatively, the average IOP was 20.24 (17.74~23.52) mmHg and 24.24 (20.52~27.40) mmHg in group A and group B, respectively.

(t = 1.637, *P* = 0.106; t = 1.981, *P* = 0.051; respectively).

Besides, under the routine gonioscopy examination, open angle was observed in both groups postoperatively. No obviously presence of goniosynechiae appeared in both group A and group B, with angle closure < 180°. Meanwhile, the degree of angle opening postoperatively in all patients increased as compared with the pre-operative level.

Surgical complications

Post-operatively, transient high IOP was observed in group A (3 eye) and group B (0 eye), which was controlled after the administration of timolol eye drops. Anterior chamber fibrin exudation occurred in group A (2 eye) and group B (4 eyes), which disappeared after administrating with corticosteroid and non-steroid eye drops. Occurrence of corneal bedewing was observed in 4 eyes in group A, and 6 eyes in group B; and recovery was achieved through the application of local hormone treatment using the corticosteroid hormone such as glucocorticoid, hypertonic saline and other conservative treatment. Statistical difference was detected between group A and group B in the term of the incidence of complications (χ^2 = 6.159, *P* = 0.046); however, regarding the comparison of different complications between group A and group B separately, results indicated none obviously statistical difference (all *P* > 0.05). Further, there was no incidence of intra-operative posterior capsular rupture; no post-operative iris adhesion; as well as no occurrence of endophthalmitis and retinal detachment post-operatively.

Discussion

Cataract and glaucoma are leading causes of blindness worldwide and are observed to have a high incidence amongst the over 40 year's old individuals, and their co-existence is common in clinical practice [19]. They are accompanied with sudden typical angle closure attack, peripheral iris obstruction of the trabecular meshwork that contribute to the blockage of anterior aqueous flow and elevated IOP [20, 21]. Angle structure, ACD, AOD, lens position and the iris structure is therefore becoming the major factors of angle closure [22]. For senile

glaucoma with concomitant cataract patients with short eye axis, small corneal, shallow anterior chamber and narrow chamber angle, the relative location of lens moved forward caused by the decreased anterior chamber depth, increased lens thickness and relaxed suspensory ligament of the optic lens [23]. In this regard, the contact between the pupil and the lens is close to the surface of the lens, and is therefore usually associated with high IOP that results from an increased venous outflow resistance, which is often the primary cause of ACG [24].

Surgical treatment has been proved to accelerate disease progression. This study was designed to explore the efficacy of phacoemulsification combined with intraocular lens implantation alone or associated with vitreous aspiration. Notably, phacoemulsification combined with intraocular lens implantation associated with vitreous aspiration was adopted in group B, relevant reason was that even initial drug intervention was done, the preoperative IOP in this group was still relatively higher. Major results of this study suggested that both surgical therapies may help to the substantial visual recovery, excellent IOP control, and decreased extent of synechial angle closure with few complications for treatment of ACG with concomitant cataract. ACG with concomitant cataract is generally characterized with the relatively thickness and front position of lens [25]. Lens extraction and intraocular lens implantation hence result in deepened central ACD, relative flat position of the pupil edge, relieved pupil blocking, which to a certain extent lead to the relieved anterior chamber angle, and the opening of the anterior chamber angle, so as to achieve intraocular drainage angle [26]. With respect to this, phacoemulsification combined with intraocular lens implantation alone could relieve pupillary block to reopen the anterior chamber angle or reduce the adhesion and finally normalization of IOP for the patients of ACG with concomitant cataract [27]. Besides, this surgery might also contribute to the removing of the lens opacity effects on visual function, thus significantly improve the postoperative visual function [28].

During the experiment, we found that routine phacoemulsification combined with intraocular lens implantation alone can only help to the

release of the anterior aqueous flow. However, it cannot successfully reduce the volume of liquid glass, vitreous volume expansion, as well as forwarded anterior hyaloid membrane. Besides, the effect of vitreous aspiration in angle closure glaucoma is to control intraocular IOP. In the study, preoperative IOP values in group B was still high after drugs treatment, it may be necessary to apply vitreous aspiration targeting a relatively high intraocular pressure in those included patients. We hence divided experimental groups based on the preoperative IOP levels, with which patients showed relatively higher IOP underwent vitreous aspiration followed by phacoemulsification combined with intraocular lens implantation. And the results documented that following the scleral puncture closure with extra sutures and after the needle inserted into the anterior chamber through a limbal puncture, both the presence of shallow anterior chamber and elevated IOP were seen during the process. In contrast, with the performance of needle puncture and vitreous aspiration, rapid injection of viscoelastic agent from the cornea would help to the recovery of the anterior chamber and IOP from the corneal puncture, and complications such as bleeding, retinal detachment were avoided [29, 30].

In conclusion, phacoemulsification combined with intraocular lens implantation alone or associated with vitreous aspiration both resulted in substantial visual recovery, excellent IOP control, and decreased extent of synechial angle closure. Besides, phacoemulsification combined with intraocular lens implantation would be more efficacious lowering complication rates in ACG patients with concomitant cataract. Cautiously and importantly, further comprehensive studies should be conducted to explore more available therapeutic options in the treatment of ACG with concomitant cataract associated with long-term follow-up data.

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Disclosure of conflict of interest

None.

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