• Clinical Research •

Outcomes of 1.8-3.0 mm incision phacoemulsification combined with trabeculectomy for primary angle-closure glaucoma with cataract

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Abstract

● **AIM:** To compare efficacy of coaxial microincisions (1.8 mm, 2.2 mm) and small incisions (3.0 mm) on phacoemulsification combined with trabeculectomy for primary angle-closure glaucoma (PACG) with cataract.

● **METHODS:** Ninety-six patients (96 eyes) with PACG and cataract were recruited and randomly divided into three groups between January 2015 and June 2017. Group A (3.0 mm incision), B (2.2 mm incision), and C (1.8 mm incision) comprised 30, 34 and 32 eyes respectively. All cases were treated with clear corneal incision phacoemulsification combined with trabeculectomy. Data including best corrected visual acuity (BCVA), corneal astigmatism, corneal endothelial cell counts (CECC), intraocular pressure (IOP), and complications were collected before the operation, and at postoperative 1d, 1 and 3mo.

● **RESULTS:** All the patients were successfully treated with surgery. The BCVA of groups B and C were significantly improved as compared to group A at postoperative 1d, 1 and 3mo (all $P<0.05$), but there was no difference between groups B and C at each time interval (all $P>0.05$). The corneal astigmatism of group A was statistically higher than that of group B ($P=0.026$); corneal astigmatism of group B was statistically higher than that of group C at postoperative 1d ($P=0.006$). The corneal astigmatism of group A at postoperative 3mo was significantly higher than that before operation ($P=0.003$). At postoperative 1 and 3mo, corneal astigmatism of groups B and C were significantly lower than that of group A (all $P<0.05$). The CECC in group B was significantly higher than that of group A ($P=0.020$), and CECC in group C was significantly higher than that of group B ($P=0.034$) at postoperative 1d. At postoperative 1 and 3mo, CECC of groups B and C were significantly higher than that of group A (all $P<0.05$). In each group, postoperative mean IOP at each time interval was significantly lower than preoperative IOP (all $P<0.05$).

● **CONCLUSION:** Coaxial microincision phacoemulsification combined with trabeculectomy for PACG with cataract has better curative efficacy in reducing postoperative corneal astigmatism and corneal endothelial cell injury than traditional small incision combined surgery, and the 1.8 mm microincision has better curative efficacy than 2.2 mm microincision in the early postoperative period.

● **KEYWORDS:** coaxial microincision; glaucoma; cataract; phacoemulsification; trabeculectomy

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INTRODUCTION

Cataract and glaucoma are the most common causes of visual impairment worldwide. Co-existence of cataract and glaucoma is a common problem in elderly people[1]. Cataract reduces vision when opacification of the crystalline lens interferes with the transmission of light to the retina. The development of cataract may cause narrowing of the anterior chamber, which is a high-risk factor for glaucoma. Glaucoma is an optic neuropathy with a characteristic pattern of damage to the optic nerve that results in irreversible vision loss. Glaucoma is categorized into open angle and closed-angle, based upon the configuration of the anterior chamber angle. Higher rates of primary angle-closure glaucoma (PACG) are reported in Asians as compared to other races[2].

The pathogenesis of cataract and glaucoma are not fully understood. Surgery is one of the primary methods to treat patients with concomitant glaucoma and cataract, especially by phacotrabeculectomy plus intraocular lens (IOL) implantation. The lens plays a major role in the pathophysiology of PACG. Cataract removal significantly deepens the anterior chamber and widens the drainage angle in patients with PACG[3-4]. Phacotrabeculectomy plus IOL implantation was shown to be more effective than trabeculectomy[5]. Numerous studies have suggested that the combined procedures may be more successful at reducing intraocular pressure (IOP) than trabeculectomy alone[6]. However, the size of clear corneal incision (CCI) of phacoemulsification was reported to affect the efficacy of surgery and change the clinical parameters of the operated eye, including best corrected visual acuity (BCVA), corneal astigmatism, corneal endothelial cell counts (CECC), IOP and complications. Some studies have shown that small incision phacoemulsification leads to less tissue damage, rapid recovery of postoperative visual function, good IOP control and less postoperative complications. Microincision has greater advantages than the small incision because of smaller wound and less tissue damage. The postoperative effects and complications associated with coaxial microincision clear corneal phacoemulsification combined with trabeculectomy have been rarely reported[7-9]. The objective of this study was to compare efficacy of 1.8 mm coaxial microincision, 2.2 mm coaxial microincision, and 3.0 mm small incision on phacoemulsification combined with trabeculectomy in the treatment of PACG combined with cataract.

SUBJECTS AND METHODS

Ethical Approval This prospective observational study was approved by the Ethics Committee of the First Affiliated Hospital of Anhui Medical University, and followed the Declaration of Helsinki. All patients signed informed consent.

Patients and Inclusion Criteria A total of 121 eyes from 121 patients underwent coaxial CCI phacoemulsification combined with trabeculectomy between 2015 and 2017. Patients were randomly assigned to three groups: 3.0 mm CCI group (group A), 2.2 mm CCI group (group B) and 1.8 mm CCI group (group C). A total of 25 eyes were excluded due to missing follow-up examinations.

All patients had a complete ocular examination before surgery, including BCVA, slit-lamp biomicroscopy, IOP (Goldmann applanation tonometer, JA-900, Switzerland), CECC (corneal endothelial microscope, EM-3000, Tomey, Japan), corneal astigmatism (corneal topography, TMS-4, Tomey, Japan), visual field and fundus oculi examination. Ultrasound biomicroscopy (UBM; SW-3200L, Suoer, China) and gonioscopy (G1, Volk, USA) were used to observe anterior chamber and the degree of goniosynechia. IOL master (500, Zeiss, Germany) was used to calculate IOL power.

The inclusion criteria were as follows: presence of cataract confirmed by slit-lamp examination, Snellen BCVA of 20/50 or worse, presenting IOP>21 mm Hg and ≤30 mm Hg under medical therapy, presenting CECC>1500/mm^2, corneal astigmatism <1.0 D and the presence of typical signs including goniosynechia ≥180°, visual field loss compatible with glaucoma and glaucomatous optic disk changes. All patients were diagnosed with PACG according to the ISGEO classification criteria. Glaucoma severity was categorized according to their mean deviation (MD) of the visual fields results as follows: mild (MD≤6 dB), moderate (MD 6-12 dB), and severe (MD>12 dB) PACG[10]. The severity of each group was moderate to severe. The lens nuclei were at grade II-III according to LOCS II standard.

Exclusion criteria: presenting IOP≤21 or >30 mm Hg, patients with congenital glaucoma, primary open angle glaucoma, history of intraocular surgery including argon laser peripheral iridoplasty or laser peripheral iridotomy, history of ocular trauma and ocular surface diseases. Patients with severe heart, liver or kidney diseases, or suffering from other major organ dysfunction. Of the subjects deemed eligible for the study, 25 subjects who missed the follow-up examinations were excluded (12 men and 13 women; age, 65±14.1y; IOP, 25.8±4.58 mm Hg).

The clinical data of 96 subjects showed that 35 patients had bilateral coexistent glaucoma and cataract. One of the two eyes met the inclusion criteria and was selected for combined surgery. The other eye did not meet the inclusion criteria, such as Snellen BCVA>20/50, or goniosynechia <180°, *etc.*, requiring other types of surgical or drug therapy. So only one eye per subject was included in the study.

Surgery Technique Briefly, the surgical procedure was as follows: under peribulbar anesthesia (2% xylocaine, 0.75% bupivacaine), a fornix-based conjunctival flap was created, incising the conjunctiva and Tenons capsule at the limbus at the 12 o'clock position. A 3.0 mm by 4.0 mm half-thickness scleral flap was dissected. The dissection was performed 1.0-2.0 mm into the clear cornea. In group A, a diamond keratome was used to form 3.0 mm CCI for phacoemulsification at 11 o'clock position. In group B, 2.2 mm CCI was performed at 11 o'clock position. In group C, 1.8 mm CCI was performed as described above. The anterior chamber was opened through the corneal tunnel and inflated with viscoelastic (Iviz, Bausch & Lomb Freda, China). A standard capsulorhexis and hydrodissection of the nucleus was performed through the corneal tunnel. Phacoemulsification was also performed. The mean phacoemulsification time was 23.2±6.3s, and the mean ultrasound power (%) was 21.1±5.2. A foldable IOL was implanted in the capsular bag. In group A, a foldable IOL (Akreos AO, Bausch & Lomb, USA) was used. In groups B and C, another foldable IOL (Akreos MI60, Bausch & Lomb, USA) was used. A trabeculectomy of 2.0 mm by 0.8 mm was performed with the diamond knife. Then a peripheral iridectomy was performed with the corneal scissors. The scleral flap was closed with two 10.0 nylon sutures that allowed guarded filtration of aqueous humor. At the end of surgery, the fornix-based conjunctival flap was closed with continuous suture.

All operations were performed by the same surgeon. Postoperatively, the patients were treated with ciprofloxacin 0.3% four times daily for two weeks. Tobramycin drops and prednisolone acetate ophthalmic suspension were administrated six times a day and reduced within 4-6wk depending on the degree of postoperative inflammation.

Postoperative evaluations of BCVA, corneal astigmatism, CECC, IOP and complications were performed at postoperative 1d, 1 and 3mo.

Statistical Analysis Statistical analysis was performed using the SPSS 17.0 for Windows software (SPSS, Inc., Chicago, IL, USA). Data were expressed as the mean±SD. Statistics of BCVA were calculated on the basis of logMAR values. Differences between preoperative and postoperative values for BCVA (logMAR), corneal astigmatism, CECC, and IOP were analyzed by one-way analysis of variance (ANOVA) for repeated measures, and LSD method was used for multiple comparisons in both ANOVA and repeated measures. The Chi-square test was used for proportional variables. $P<0.05$ was considered statistically significant.

RESULTS

A total of 96 eyes of 96 patients were enrolled and followed-up for six months in this study. There were 30 eyes in group A, 34 eyes in group B and 32 eyes in group C. Patient demographics are summarized in Table 1. The groups were comparable in terms of average age, gender distribution, nuclear firmness, glaucoma severity and the number of preoperation drugs. There were no significant differences in the preoperative clinical data including BCVA, corneal astigmatism, CECC and IOP among the groups.

The average BCVA (logMAR) at various intervals of the three groups is shown in Table 2. The BCVA in each group typically improved at postoperative 3mo. The postoperative BCVA (logMAR) of groups B and C were significantly better than that of group A at the same time point (all $P<0.05$), while there was no significant difference in BCVA between groups B and C (all $P>0.05$).

The average corneal astigmatism of the three groups at various time intervals is shown in Table 3. The corneal astigmatism of group A was higher at each postoperative follow-up than baseline. The corneal astigmatisms of groups B and C were significantly increased at postoperative 1d, while there was no difference between the other follow-ups and baseline. The corneal astigmatism of group A was statistically higher than that of group B ($P=0.026$), corneal astigmatism of group B was statistically higher than that of group C at postoperative 1d ($P=0.006$). Corneal astigmatism of groups B and C returned to baseline level at postoperative 3mo (both $P>0.05$), while the corneal astigmatism of group A at postoperative 3mo was significantly higher than baseline ($P=0.003$). At postoperative 1 and 3mo, corneal astigmatism of groups B and C were not significantly different (both $P>0.05$), and were lower than that of group A (all $P<0.05$).

Table 1 Summary of characteristics of each group

Parameters	Group A (*n*=30)	Group B (*n*=34)	Group C (*n*=32)
Gender			
M	13	16	16
F	17	18	16
Age (y)			
Mean	65.7±15.6	67.9±13.1	65.3±12.8
Range	51-75	47-73	50-75
Severity, *n* (%)			
Moderate (MD 6-12 dB)	20 (66.7)	22 (64.7)	22 (68.8)
Severe (MD >12 dB)	10 (33.3)	12 (35.3)	10 (31.2)
LOCS II cataract grade, *n* (%)			
II	10 (33.3）	12 (35.3)	2 (37.5)
III	20 (66.7）	22 (64.7)	20 (62.5)
Mean No. of topical glaucoma medications	1.7±0.9	1.9±1.0	1.7±0.8

The average CECC at various time intervals of the three groups is shown in Table 4. Postoperative CECC decreased significantly as compared to the preoperative level (all $P<0.05$), and was the lowest on postoperative 1d in each group. CECC of groups B and C at postoperative 1d, 1 and 3mo were significantly higher than that of group A (all $P<0.05$). On postoperative 1d, CECC of group C was significantly higher than that of group B ($P=0.034$), while at postoperative 1 and 3mo, there was no significant difference between groups B and C (both $P>0.05$). In each group, postoperative mean IOP was significantly lower than preoperative IOP at each time interval (all $P<0.05$). Data are listed in Table 5.

There were no serious intra or postoperative complications in the study participants. No patient complained of obvious eye pain on the day of operation and early postoperative examination showed no increase in IOP. IOP spike did not occur in any patient after the surgery. Two eyes in group A and one eye in group B experienced shallow anterior chamber within 1wk postoperation. One eye in group B and two eyes

Table 2 The results of BCVA before and after operation logMAR

Time	Group A (n=30)	Group B (n=34)	Group C (n=32)	P_1	P_2	P_3	P_4	P_5	P_6
Preop.	0.69±0.18	0.71±0.21	0.68±0.23	0.815	0.673	0.833			
Day 1	0.51±0.16	0.41±0.14	0.38±0.15	0.032	0.026	0.774	0.021	0.019	0.014
Month 1	0.42±0.15	0.33±0.09	0.32±0.11	0.003	0.039	0.583	0.015	0.009	0.008
Month 3	0.39±0.13	0.29±0.08	0.30±0.10	0.014	0.003	0.658	0.015	0.005	0.006

P_1: BCVA of group A *vs* group B; P_2: BCVA of group A *vs* group C; P_3: BCVA of group B *vs* group C; P_4: Postop. BCVA at each time interval *vs* preop. BCVA in group A; P_5: Postop. BCVA at each time interval *vs* preop. BCVA in group B; P_6: Postop. BCVA at each time interval *vs* preop. BCVA in group C.

Table 3 Corneal astigmatism before and after operation D

Time	Group A (n=30)	Group B (n=34)	Group C (n=32)	P_1	P_2	P_3	P_4	P_5	P_6
Preop.	0.73±0.26	0.71±0.28	0.70±0.29	0.354	0.326	0.463			
Day 1	1.35±0.52	1.16±0.49	0.97±0.35	0.026	0.001	0.006	0.027	0.033	0.039
Month 1	1.14±0.47	0.79±0.32	0.78±0.38	0.017	0.003	0.353	0.031	0.061	0.052
Month 3	0.92±0.41	0.74±0.30	0.73±0.28	0.006	0.004	0.421	0.003	0.218	0.223

P_1: Corneal astigmatism of group A *vs* group B; P_2: Corneal astigmatism of group A *vs* group C; P_3: Corneal astigmatism of group B *vs* group C; P_4: Postop. corneal astigmatism at each time interval *vs* preop. corneal astigmatism in group A; P_5: Postop. corneal astigmatism at each time interval *vs* preop. corneal astigmatism in group B; P_6: Postop. corneal astigmatism at each time interval *vs* preop. corneal astigmatism in group C.

Table 4 CECC before and after operation cells/mm^2

Time	Group A (n=30)	Group B (n=34)	Group C (n=32)	P_1	P_2	P_3	P_4	P_5	P_6
Preop.	2265.6±345.9	2287.7±309.9	2261.4±362.8	0.133	0.089	0.071			
Day 1	1832.0± 279.8	2003.6±358.4	2097.8±346.1	0.020	0.023	0.034	0.011	0.004	0.008
Month 1	2007.9±380.3	2158.6±351.2	2174.3±365.8	0.004	0.003	0.221	0.004	0.028	0.031
Month 3	1925.6±321.7	2099.3±396.4	2120.9±380.3	0.012	0.009	0.239	0.003	0.009	0.015

P_1: CECC of group A *vs* group B; P_2: CECC of group A *vs* group C; P_3: CECC of group B *vs* group C; P_4: Postop. CECC at each time interval *vs* preop. CECC in group A; P_5: Postop. CECC at each time interval *vs* preop. CECC in group B; P_6: Postop. CECC at each time interval *vs* preop. CECC in group C.

Table 5 IOP before and after operation mm Hg

Time	Group A (n=30)	Group B (n=34)	Group C (n=32)	P_1	P_2	P_3	P_4	P_5	P_6
Preop.	26.36±3.41	25.70±4.08	25.13±3.93	0.631	0.689	0.628			
Day 1	13.96±3.32	14.40±3.43	15.11±3.64	0.279	0.236	0.215	0.007	0.009	0.013
Month 1	15.98±3.57	16.10±3.78	16.53±3.97	0.411	0.365	0.437	0.011	0.016	0.017
Month 3	16.74±3.71	16.49±3.36	17.16±3.51	0.388	0.374	0.316	0.015	0.017	0.021

P_1: IOP of group A *vs* group B; P_2: IOP of group A *vs* group C; P_3: IOP of group B *vs* group C; P_4: Postop. IOP at each time interval *vs* preop. IOP in group A; P_5: Postop. IOP at each time interval *vs* preop. IOP in group B; P_6: Postop. IOP at each time interval *vs* preop. IOP in group C.

in group C showed mild anterior chamber hyphema within 3d post-operation. Two eyes in each group showed corneal edema within 3d post-operation.

DISCUSSION

This study showed that coaxial microincision phacoemulsification combined with trabeculectomy has better efficacy in reducing postoperative corneal astigmatism and corneal endothelial cell injury. The results suggested that the smaller the incision, the quicker was the healing and lower was the corneal astigmatism, which were useful for patients.

At present, three surgical methods are used for the treatment of PACG complicated with cataract. First, cataract phacoemulsification or trabeculectomy is performed alone. Second, glaucoma surgery and cataract extraction are separately performed. Third, combined surgery of cataract and glaucoma is simultaneously performed. Studies have shown that phacoemulsification combined with trabeculectomy has rapid postoperative recovery, better IOP control, and fewer postoperative complications[11-13]. It is widely used in the treatment of PACG combined with cataract.

The microincision is very useful for postoperative recovery in cataract surgery[14-15]. An incision <2.2 mm is named microincision. It can effectively reduce astigmatism and the occurrence of endophthalmitis. However, if the size of the microincision is too small, it is difficult to conduct the surgery and often causes some complications including corneal endothelial damage and difficulty for central continuous curvilinear capsulorhexis. Therefore, suitable size of microincision is critical for surgery. This study compared the effects of 1.8 mm microincision, 2.2 mm microincision, and 3.0 mm incision on postoperative visual acuity, corneal astigmatism, CECC, IOP, and complications.

Some factors were related to the recovery of visual acuity including surgery-induced astigmatism, corneal injury, and postoperative complications. As these factors were caused by the size of microincision[16], the microincision size is one of the important factors influencing vision[17]. Allan and Barrett[18] showed that astigmatism after small incision phacoemulsification combined with trabeculectomy was increased by only 0.5 D. Microincision phacoemulsification combined with trabeculectomy can reduce surgical damage to the cornea and other tissues. The effect of cornea incision on the postoperative CECC is controversial. Hayashi *et al*[19] showed that decreasing the incision length and increasing the tightness of anterior chamber were conducive to reduce the damage to the cornea. Meta-analysis by Shentu *et al*[20] revealed that postoperative 7 and 30d CECC showed no significant difference between the microincision group and the small incision group, but the microincision group showed more injury on CECC at postoperative 60d. In addition, Hwang *et al*[21] found that the blood aqueous barrier was more susceptible to destruction in the microincision group as compared to the small incision group. The destruction of the blood aqueous barrier and the release of inflammatory factors may be another reason for the high endothelial cell loss percentage in the microincision group. The results of this study suggested that microincision reduced the corneal astigmatism and decrease of CECC. These findings were similar to the result of Meta-analysis by Shentu *et al*[20].

IOP control is an important indicator of successful operation. The present study showed that either coaxial microincision or small incision phacoemulsification combined with trabeculectomy could achieve IOP reduction effect. There was no difference among the groups, which indicated that the incision had no effect on IOP.

There is no consensus on whether the combined operation or the staged operation is more effective in reducing IOP. Gdih *et al*[22] proved that the effect of simple trabeculectomy on reducing IOP was greater than that of combind surgery. For patients with advanced glaucoma, lower target IOP is required, and the cataract operation is recommended after the IOP is stabilized. Chen *et al*[23] pointed out that anti-glaucoma surgery first will accelerate the development of cataracts, but phased surgery for glaucoma and cataract has fewer complications and higher safety than combined surgery. With the improvement of surgical techniques, phacoemulsification combined with trabeculectomy has been gradually recognized as superior to phased surgery in improving visual acuity and controlling IOP[24-25].

The mechanism of IOP reduction by combined surgery may be as follows. First, the effect of thickened lens on the incidence of angle closure glaucoma is relieved. The IOL is thinner than the lens, and the gap between the iris and IOL increases, which may relieve the pupillary block. Second, viscoelastic separate the chamber angles to exposed trabecular meshwork. Third, phacoemulsification is a completely closed operation. The pressure of the perfusion fluid and repeated flushing can reduce the anterior chamber adhesion and peripheral anterior synechia of iris. Fourth, the anterior chamber becomes wider and deeper, and the iris root is flattened. The choroid and scleral passages are opened, and then IOP is effectively reduced. Fifth, if phacoemulsification is performed alone, the chamber angle cannot be opened wide enough to reduce IOP. In such case, trabeculectomy should be simultaneously performed to increase the external drainage and reduce IOP[26-28].

In this study, the complications in each group were mild, and rapidly disappeared after clinical treatment. It indicated that either coaxial microincision or small incision phacoemulsification combined with trabeculectomy was safe. As a prospective study, this study had some limitations. First, the angle of the chamber and anterior chamber depth were not examined after surgery. A detailed evaluation of changes in gonioscopic appearance and anterior chamber depth after combined surgery might be helpful in clarifying the relationship between the changes in anterior chamber depth, angle of the chamber, and the change of IOP. Second, the follow-up time was relatively short. Long-term follow-up will be performed in the future. Third, the sample size of this study was small, and the majority of patients were residents of Anhui Province. The results of the present study need to be confirmed by large sample size and multi-center studies.

In summary, coaxial microincision phacoemulsification combined with trabeculectomy for PACG with cataract had better visual acuity, smaller corneal astigmatism and less corneal endothelial injury post-operation than traditional small incision combined surgery. There was no significant difference in IOP reduction. The advantage of 1.8 mm microincision was more obvious than that of 2.2 mm microincision in the early postoperative period.

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