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Original Article

The efficacy of ultrasonic emulsification with IOL implantation in patients with primary angle-closure glaucoma combined with cataract

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Abstract: Purpose: This study aimed to investigate the clinical efficacy of ultrasonic emulsification plus IOL implantation in patients with primary angle-closure glaucoma and cataract. Methods: The clinical data of 81 patients (91 eyes) with primary angle-closure glaucoma comorbid with cataract in our hospital were retrospectively analyzed and divided into two groups based on surgical modality. Group A (n=40, 45 eyes) underwent trabeculectomy and group B (n=41, 46 eyes) underwent ultrasonic emulsification and IOL implantation. The success rate, best corrected visual acuity, intraocular pressure, anterior chamber depth, anterior chamber angle, visual field, cornea's endothelial cell count, complications, and patient satisfaction were compared between the two groups. Results: The surgical success rate in group B was 97.83%, significantly higher than 86.67% in group A ($P < 0.05$); Compared with group A, group B had higher best-corrected visual acuity and lower intraocular pressure ($P < 0.05$) as well as higher central and peripheral anterior chamber depths at 3 months postoperatively ($P < 0.05$); After surgery, group A had significantly lower postoperative cornea's endothelial cell count ($P < 0.05$). Compared with group A, MS was higher and MD was lower in group B at 3 months postoperatively ($P < 0.05$); the complication rate in group B was 8.70%, lower than 28.89% in group A ($P < 0.05$). Conclusion: The clinical efficacy of ultrasonic emulsification combined with IOL implantation is remarkable in patients with primary angle-closure glaucoma and cataract, which is conducive to improving postoperative visual acuity, lowering intraocular pressure, increasing the atrial angle, and improving visual field defects. It is also with high safety, but has little effect on cornea's endothelial cell count.

Keywords: Primary, angle-closure, glaucoma, cataract, ultrasonic emulsification, IOL implantation

Introduction

Glaucoma, a ophthalmic disease with high morbidity, is characterized by visual field defect with optic nerve damage caused by pathologically elevated intraocular pressure [1]. The most common type of glaucoma in China is primary angle-closure glaucoma, which has been ranked by the World Health Organization as the second leading cause of blindness globally [2, 3]. Patients with glaucoma are usually accompanied by cataracts, which are mainly associated with factors such as impairment of venous drainage and coronary flow impairment [4]. Secondly, during an acute attack of glaucoma, glaucomatous fleck is observed on the surface of the anterior crystal capsule, which contributes to the development of cataract [5]. Long-term treatment with anti-glaucoma drugs will also promote the rapid formation of nuclear cataracts [6].

Surgery is a common treatment option for primary angle-closure glaucoma plus cataract. Traditional surgical procedures include peripheral iridotomy and filtration procedures, such as drainage valve implantation and trabeculectomy [7, 8]. Although this type of surgical treatment can achieve target IOP in some patients, it can also induce complications such as infection of endophthalmitis, bleb leaks, shallow anterior chamber, choroidal detachment, scleral scarring, and accelerated cataract development. The postoperative vision is also difficult to maintain in patients with primary angle-closure glaucoma combined with cataract. Therefore, the above surgical methods have limitations in clinical application [9, 10].

In recent years, ultrasonic emulsification has emerged as a useful tool, and exhibits advantages such as less surgical trauma, closed surgery, and rapid stabilization of IOP. This will significantly reduce the postoperative inflammatory response and also widen the atrial angle, allowing the pupillary block to be effectively improved, and thus widely used in the treatment of primary angle-closure glaucoma comorbid with cataract [11]. To further improve the effect of surgical treatment, this study combined intraocular lens implantation with this surgical approach to enlarge the anterior chamber volume, deepen the peripheral and central anterior chamber, make more room for the iris to move backwards, thus the pupil block can be relieved.

Materials and methods

Data

The clinical data of 81 patients (91 eyes) with primary angle-closure glaucoma comorbid with cataract in our hospital were retrospectively analyzed and divided into two groups based on surgical modality. Group A (n=40, 45 eyes) underwent trabeculectomy and group B (n=41, 46 eyes) received ultrasonic emulsification and IOL implantation (1) Inclusion criteria: informed consent was obtained; no contraindication to surgery; angle closure confirmed by atrial angioscopy; history of glaucoma episodes with poor IOP control by medication or intolerance to medication; approval by the medical ethics committee of The First People's Hospital of Fuyang District. (2) Exclusion criteria: suffering from systemic diseases such as diabetes mellitus, cardiovascular and cerebrovascular diseases, severe renal disease; low cooperation; suffering from other ocular diseases such as endophthalmitis and uveitis; previous correction of refractive error by excimer laser, vitrectomy, anti-glaucoma surgery, etc.

Methods

Group A received related examinations before operation to exclude surgical contraindications. Intraocular pressure lowering medications and antibiotic eye drops were prescribed for treatment; Under supine position, routine disinfection and draping was performed, followed by topical anesthesia combined with retrobulbar anesthesia after administration of miotics. Ophthalmologic retractor was used for retaining primarily the upper eyelid and eyelashes; A 3×4 mm trapezoidal scleral flap (corneal limbus as the base) with 50% of the iris thickness and fornix based conjunctival flap were created; Another clear corneal incision was made to perform anterior chamber puncture. After a small amount of aqueous humor is slowly released, the trabecular tissue (size 1.5×1.5 mm) is removed, and then the peripheral iris was cut off. Finally the conjunctival flap and iris flap were sutured.

Preoperative examination was performed as well, excluding surgical contraindications. Levofloxacin eye drops (H20103148, Jiangsu Hanchen Pharmaceutical Co., Ltd. Specification: 5 mL) were administrated Q.I. D for 3 days. Half an hour before the operation, the patient was given an intravenous infusion of 250 mL of 20% mannitol (H42022506, Huazhong Pharmaceutical Co., Ltd. 250 ml) to promote vitreous condensation and reduce posterior pressure. Proparacaine eye drops (H20084062, Suzhou Industrial Park Tianlong Pharmaceutical Co., Ltd., 0.50%) was used for surface anesthesia. A limbal incision and temporal corneal tunnel were created and the anterior chamber was punctured with a keratome (3.2 mm). Continuous circular capsulorhexis was performed after injection of viscoelastic agents, followed by aqueous humor leakage and phacoemulsification of crystals. Cortex injection was performed and the capsular bag is expanded with viscoelastic agent, in which a folding posterior chamber intraocular lens is implanted. The position of the intraocular lens is adjusted, and the viscoelastic agent is flushed before the corneal incision is closed.

Outcome measurement

(1) Criteria for the success of surgery [12]: IOP < 20 mmHg, unchanged or enlarged visual field of the operated eye, and formation of functional filtration follicles; Otherwise, it indicated failure of surgery. (2) Best-corrected visual acuity was measured in the two groups using the international standard visual acuity chart before and 3 months after surgery, respectively. (3) IOP levels were measured in both groups before and 3 months after surgery using a non-contact IOP meter, respectively. (4) Anterior chamber depth: The central and peripheral anterior chamber depth were measured by UBM (ultra-

Table 1. Comparison of baseline data [n (%)]/($\overline{x}$ ± s)

Data		Group A (n=40)	Group B (n=41)	t/X^2	P
Gender	Male	23 (57.50)	25 (60.98)	0.101	0.750
	Female	17 (42.50)	16 (39.02)		
Age (years)		68.15 ± 3.29	68.19 ± 3.25	0.055	0.956
Duration of illness (years)		3.38 ± 0.12	3.41 ± 0.11	1.173	0.244
Type of disease (cases)					
Acute primary angle-closure glaucoma		21 (52.50)	23 (56.10)	0.106	0.745
Chronic primary angle-closure glaucoma		19 (47.50)	18 (43.90)		

Table 2. Comparison of surgical success rate [(%)]

Grouping	Number of eyes	Success	Failure
Group A (n=40)	45	39 (86.67)	6 (13.33)
Group B (n=41)	46	45 (97.83)*	1 (2.17)*
X^2		3.989	
P		0.046	

Note: *compared with group A, $P < 0.05$.

sound biomicroscopy) in both groups before and 3 months after surgery, respectively. (5) Anterior angle was measured in both groups before and 3 months after surgery using Pentacam® HR, a high-resolution rotating Scheimpflug camera system for anterior segment analysis. (6) Corneal endothelial cell count [13] was measured in the central zone of the cornea before and 3 months after surgery, respectively. Three corneal images were collected, and the image with the highest clarity and contrast was retained for quantitative analysis and detection of corneal endothelial cell count using a corneal endothelial morphology computer. (7) Visual field: Mean sensitivity (MS), mean deviation (MD) were measured in both groups preoperatively and 3 months postoperatively. (8) Complications, including corneal edema, anterior chamber inflammation, and shallow anterior chamber, were measured. (9) Patient satisfaction: Postoperative satisfaction was investigated on patients, which was divided into three criteria: very satisfied, basically satisfied and dissatisfied. Total satisfaction = very satisfied + basically satisfied.

Statistical methods

SPSS22.0 was used to analyze the data. Graphpad Prism 8 was used for graph plotting. Measurement data was expressed as Mean ± standard deviation with t-test for normally distributed data and Mann-Whitney U test for non-normally distributed data; Count data was expressed as [n (%)] with X^2 test for comparison between the two groups. $P < 0.05$ indicates the existence of statistical significance.

Results

Comparison of baseline data

Group A included 23 males and 17 females, with an average age of (68.15 ± 3.29) years. Group B included 25 males and 16 females, with an average age of (68.19 ± 3.25) years. There was no significance in baseline data such as gender, age, course of disease, and disease type between the two groups ($P > 0.05$) (**Table 1**).

Comparison of surgical success rate and complications between the two groups

The success rate of group B was 97.83%, which was significantly higher than 86.67% in group A, showing significant difference ($P < 0.05$) (**Table 2**). The complication rate in group B was 8.70%, which was lower than 28.89% in group A, indicating significant difference ($P < 0.05$) (**Table 3**).

Comparison of best corrected visual acuity and IOP

Best-corrected visual acuity was improved and IOP was lowered in both groups at 3 months after surgery compared with before surgery ($P < 0.05$); they were better in group B at 3 months after srugery compared with group A ($P < 0.05$) (**Figure 1**).

Comparison of anterior chamber depth

Central and peripheral anterior chamber depths were higher in both groups at 3 months after

Table 3. Comparison of complications [(%)]

Grouping	Number of eyes	Corneal edema	Anterior chamber inflammation	Shallow Anterior chamber	Total incidence
Group A (n=40)	45	2 (4.44)	3 (6.67)	8 (17.78)	13 (28.89)
Group B (n=41)	46	1 (2.17)	2 (4.35)	1 (2.17)	4 (8.70)*
X^2					6.106
P					0.013

Note: *compared with group A, *P* < 0.05.

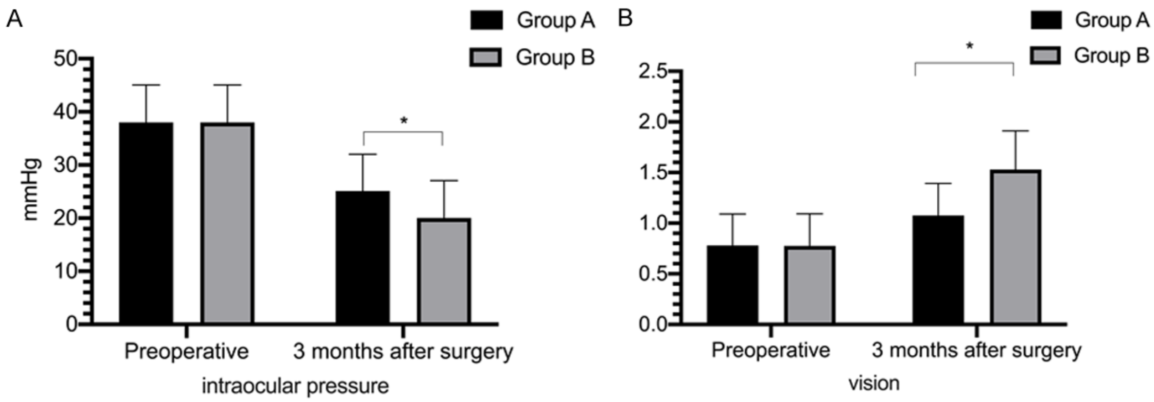

Figure 1. Comparison of best-corrected visual acuity and IOP between the two groups. No significant difference was found in IOP and best-corrected visual acuity between the two groups before surgery (*P* > 0.05). At 3 months after surgery, group B exhibited lower LOP and higher best-corrected visual acuity than group A (*P* < 0.05). A: IOP; B: Best-corrected visual acuity. Note: *compared with group A, *P* < 0.05.

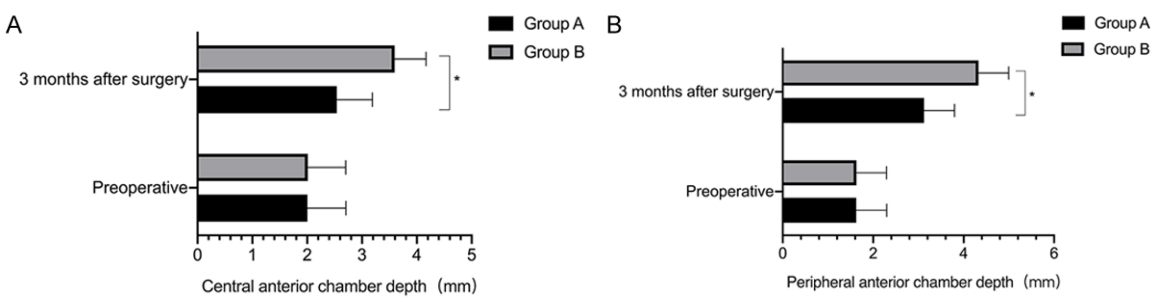

Figure 2. Comparison of anterior chamber depth. No significant difference was found in central and peripheral anterior chamber depths between the two groups before surgery (*P* > 0.05). At 3 months after surgery, group B exhibited greater central and peripheral anterior chamber depths than group A (*P* < 0.05). A: Central anterior chamber depth; B: Peripheral anterior chamber depth. Note: *compared with group A, *P* < 0.05.

surgery (*P* < 0.05) and they were higher in group B than in group A at 3 months after surgery (*P* < 0.05) (**Figure 2**).

Comparison of anterior chamber angle and corneal endothelial cell count

Compared with before surgery, the anterior chamber angle became larger in both groups at 3 months after surgery (*P* < 0.05); Compared with group A, the anterior chamber angle opening was greater in group B at 3 months postoperatively (*P* < 0.05); Compared with before surgery, corneal endothelial cell counts did not change much after surgery (*P* > 0.05); Compared with the before surgery, corneal endothelial cell count was significantly reduced in group A after surgery (*P* < 0.05). However, it did not change significantly in group B (*P* > 0.05) (**Figure 3**).

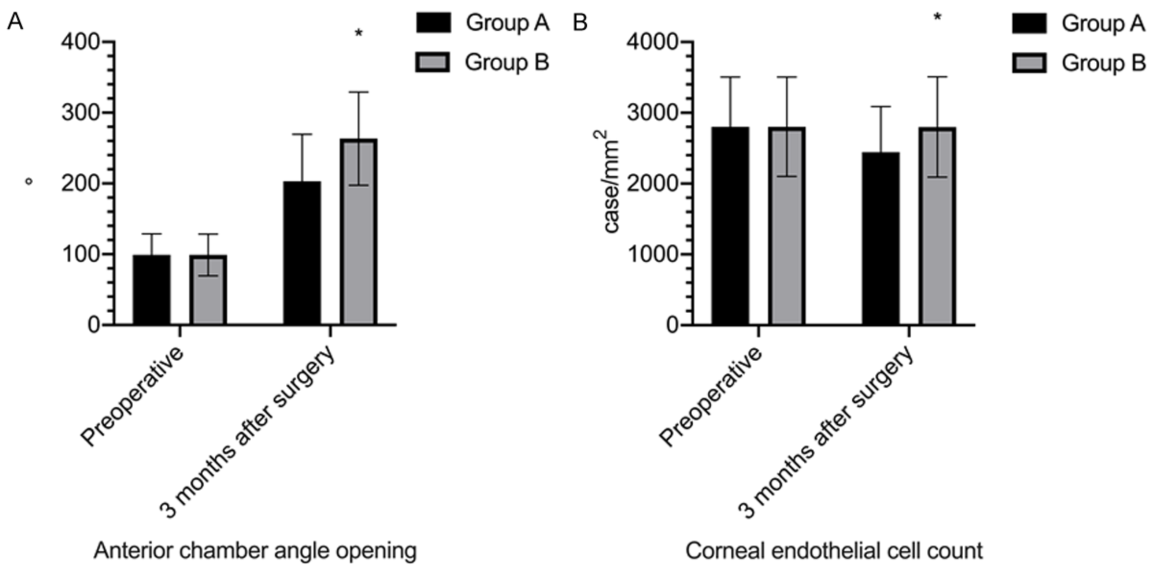

Figure 3. Comparison of anterior chamber angle and corneal endothelial cell count between the two groups. No significant difference was found in anterior chamber angle and corneal endothelial cell count between the two groups before surgery ($P > 0.05$). At 3 months after surgery, group B exhibited greater anterior chamber angle and corneal endothelial cell count than group A ($P < 0.05$). A: Anterior; B: Corneal endothelial cell count. Note: *compared with group A, $P < 0.05$.

Comparison of the visual fields

Compared with before surgery, MS increased and MD decreased in both groups at 3 months after surgery ($P < 0.05$); Compared with group A, MS in group B was higher, and MD was lower ($P < 0.05$) at 3 months after surgery (**Figure 4**).

Comparison of patient satisfaction between the two groups

After surgery, group A had 18 cases of very satisfaction, 11 cases of basic satisfaction, and 16 cases of dissatisfaction, with the total satisfaction of 64.66%, while group B had 29 cases of very satisfaction, 17 cases of basic satisfaction, and 2 cases of dissatisfaction, with the total satisfaction of 95.62%. Group B had a higher satisfaction than group A ($P < 0.05$) (**Table 4**).

Discussion

Primary closed-angle glaucoma is the most prevalent type of glaucoma in China and can be classified into two types, acute closed-angle glaucoma and chronic closed-angle glaucoma [14, 15]. Trabeculectomy is a traditional surgical procedure for the clinical treatment of glaucoma, which brings down the intraocular pressure via external drainage. However, it is highly susceptible to complications such as filtering bleb scar, macular edema, malignant glaucoma, choroidal detachment, shallow anterior chamber, and transient hypotony. Postoperative cataract development is extremely accelerated and usually requires second session of cataract surgery [16, 17]. Pupillary block is the main pathogenesis of primary angle-closure glaucoma, and lens changes also contribute to the development of pupillary block [18]. As we age, the lens gradually expands and enlarges, making the anterior chamber shallower, the pupillary block more severe, and the atrial angle closed or narrowed, increasing the IOP [19]. It has been suggested that patients with primary angle-closure glaucoma have relatively small corneas and short ocular axis, making the lens move forward, the anterior chamber shallow, and the incidence of pupillary block high, rapidly increasing IOP [20]. IOP control can be achieved by removing the lens to deepen the anterior chamber and widen the atrial angle, leading to relief of the crowded anterior segment and improvement of the pupillary block [21].

In recent years, the role of cataract surgery in controlling IOP in the treatment of primary

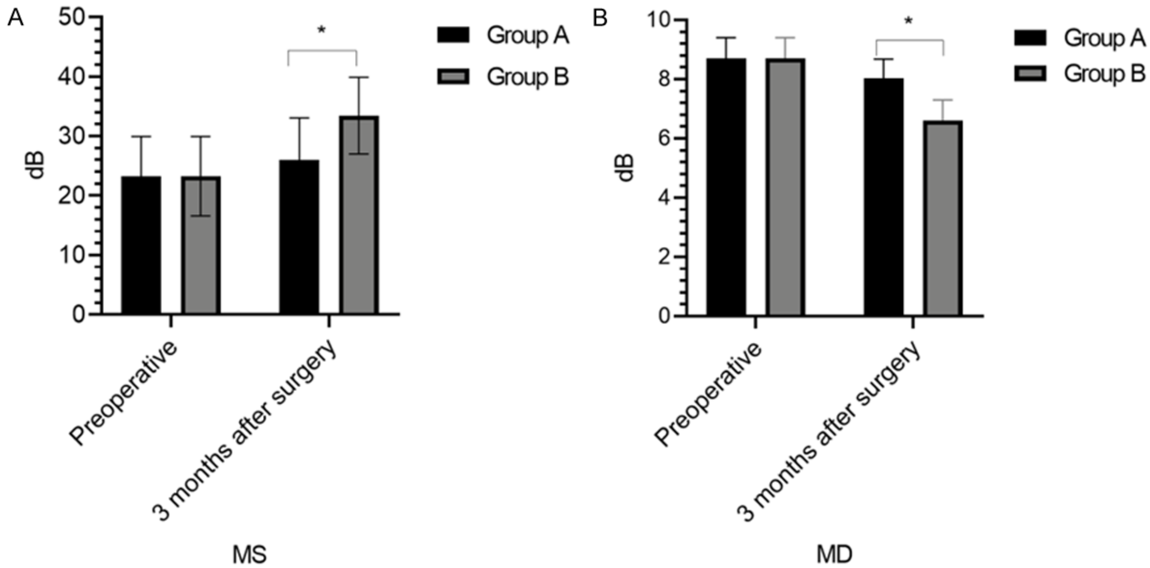

Figure 4. Comparison of visual acuity. No significant difference was found in MS and MD between the two groups before surgery (*P* > 0.05). At 3 months after surgery, group B exhibited higher MS and lower MD than group A (*P* < 0.05). A: MS; B: MD. Note: *compared with group A, *P* < 0.05.

Table 4. Comparison of patient satisfaction between the two groups [(%)]

Group	Number of eyes	Very satisfied	Basically satisfied	Dissatisfied	Total satisfaction
Group A (n=40)	45	18 (40.00)	11 (24.44)	16 (35.56)	29 (64.44)
Group B (n=41)	46	29 (63.04)	17 (36.96)	2 (4.35)	44 (95.62)*
X^2					13.962
P					< 0.001

Note: *compared with group A, *P* < 0.05.

closed-angle glaucoma has been widely recognized by most clinical scholars [22, 23]. Ultrasonic emulsification has many advantages such as less surgical trauma, mild postoperative inflammatory response, faster recovery, avoiding damage to trabecular structures and atrial angles, improving the success rate of surgery while reducing the complication rate. It has now become a common surgical procedure for the treatment of primary angle-closure glaucoma combined with cataract [24]. In this study, the results showed that the success rate of surgery, best corrected visual acuity at 3 months after surgery, central anterior chamber depth, peripheral anterior chamber depth, and MS were higher in group B than in group A, while the IOP, MD and complication rates were lower than those in group A. Although postoperative corneal endothelial cell counts were reduced, there was no significant difference compared with the preoperative period (P > 0.05), suggesting that the clinical efficacy of ultrasonic emulsification combined with IOL implantation was significant, which facilitated the improvement of postoperative visual acuity, lowered IOP, widen the atrial angle, corrected the visual field defect. The procedure is safe and has little effect on the postoperative corneal endothelial cell count. The mechanism might be summarized as follows: (1) During surgery, a thin IOL was used to replace the original swollen and thickened lens, which can release the compression of the anterior chamber angle as well as the pupillary block caused by the lens, allowing the anterior chamber depth to deepen and the anterior chamber angle to widen, resulting in a subsequent decrease in IOP [25]. (2) During the operation, blunt separation is performed on anterior chamber angle in the adhesion state, and the inflammatory mediators and iris pigment particles adhering to the angle are perfused and washed away, which can promote the increase of aqueous filtration. (3) After the procedure is completed, the peripheral portion of the lens is no longer in contact with the ciliary process, leading to the release of the ciliary ring block. (4) The ultrasonic emulsification surgery resulted in small incision and the operation is performed in a relatively confined area. Affected by the impact of perfusion water flow and ultrasonic shock, the trabecular meshwork that was already in the open state and reopened after the operation was dissolved by glycosaminoglycans. The aperture of the trabecular meshwork was significantly enlarged, and the trabecular cell division was enhanced, leading to a decrease in meshwork phagocytosis and permeability of the trabecular meshwork, promoting the outflow of aqueous humor. (5) After implantation of the IOL, the suspensory ligament of lens is also stretched tightly, which restrains the trabecular meshwork. Meanwhile, an IOL is placed in the capsular bag, which contracts and exerts pressure on the ciliary body, thereby reducing the amount of aqueous production, and the postoperative blood-aqueous barrier is subsequently altered, with a decrease in atrial aqueous secretion. (6) Following phacoemulsification surgery, a large amount of endogenous prostaglandin E2 is released, which then promotes the outflow of sclera filtering channel and reduces the intraocular pressure [26].

In conclusion, the clinical efficacy of ultrasonic emulsification combined with IOL implantation is remarkable in patients with primary angle-closure glaucoma and cataract, which is conducive to improving postoperative visual acuity, lowering intraocular pressure, widening the atrial angle, and improving visual field defects, while with high safety and little effect on cornea's endothelial cell count.

Limitations: The indications of surgical methods and long-term effects still need to be further explored.

Disclosure of conflict of interest

None.

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