Clinical efficacy of sclerotonyxis for acute angle-closure glaucoma with persistent high intraocular pressure

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Abstract. – OBJECTIVE: The aim of the study was to investigate the clinical effectiveness and safety of sclerotonyxis in acute angle-closure glaucoma (ACG) with persistent high intraocular pressure (IOP).

PATIENTS AND METHODS: The clinical data of 50 eyes from 50 patients (mean age: 68.9±7.19 years) with acute ACG and persistently high IOP who were admitted to our department between January 2012 and January 2022 were retrospectively analyzed. Patients who were administered the maximum dose of systemic and topical anti-glaucoma drugs and still had an IOP of >40 mmHg 24 hours after admission underwent sclerotonyxis. After the IOP control, an individualized phase II treatment plan was designed according to the patient's ocular condition.

RESULTS: Forty-eight patients showed improvement in their visual acuity 6 months postoperatively compared to their preoperative values. The mean IOPs were 54.84±7.82 mmHg and 21.34±7.81 mmHg 24 hours pre and postoperatively, respectively. The mean anterior chamber depth showed statistically significant differences pre and postoperatively (1.75±0.16 mm and 1.84±0.17 mm, respectively) ($p<0.05$). After IOP stabilized, four patients underwent YAG laser peripheral iridectomy, 18 underwent simple cataract phacoemulsification combined with intraocular lens (IOL) implantation, 21 underwent cataract phacoemulsification combined with IOL implantation and goniosynechialysis under a gonioscope, and 7 patients underwent combined surgery of glaucoma and cataract. The mean IOPs were 15.94±3.3 mmHg and 15.64±2.99 mmHg 1 week and 6 months after stage II surgery, respectively. Moreover, 42 eyes (84%) attained complete success and 8 eyes (16%) attained conditional success 6 months postoperatively. No serious complications, such as corneal endothelial decompensation, malignant glaucoma, vitreous or eruptive choroidal hemorrhage, and retinal detachment, were observed intraoperatively or postoperatively in both procedures.

CONCLUSIONS: Sclerotonyxis can rapidly lower IOP, release the pupillary blockage, reconstruct the anterior chamber, and reduce systemic complications caused by long-term high-dose antiglaucoma drugs. Thus, it normalizes the IOP and provides a safe operating space for stage II surgery, effectively reducing complications in patients in a persistent high IOP state.

Key Words:
Acute angle-closure glaucoma, Sclerotonyxis, Persistent high intraocular pressure.

Introduction

Acute angle-closure glaucoma (ACG) is the most primary and common irreversible disease leading to blindness in China[1]. Its pathogenesis is mainly associated with pupillary blockage due to a crystalline lens, especially during acute grand mal seizures[2]. If intraocular pressure (IOP) is controlled promptly in acute ACG, vision is gradually restored, and the visual field remains normal[3]. However, acute ACG with high IOP that is not controlled promptly may swiftly cause complete blindness[4]. Clinically, in some patients with attacks of acute ACG, IOP persists at >40 mm Hg despite the administration of the maximum safe dose of anti-glaucoma medication locally and systemically[5]. If surgery is performed in the presence of ocular tissue edema and intense congestion, a strong tissue inflammatory response causes surgical complications. Moreover, the filtering blebs are also prone to fibrous scarring and poor treatment outcomes.

Sclerotonyxis is often used to treat glaucoma patients with uncontrollable intraocular pressure[6]. The basic principle is to reduce intraocular pressure by draining the atrial fluid and reducing the volume of intraocular fluid[7]. The puncture and

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release of fluid immediately lowers intraocular pressure (IOP), rapidly relieves central retinal artery pulsation, and avoids the serious consequences of severe optic nerve damage caused by high IOP. In addition, postoperative complications are avoided. However, one of the major controversies has been the need for intraoperative fluid release. Opponents argued that releasing fluid was damaging to the eye and could cause complications such as choroidal hemorrhage[8]. With the continuous improvement of the technique, compared to keratonyxis, sclerotonyxis not only reduces the intraocular pressure and makes it easier to obtain the required height of the scleral ridge, which allows the lacunae to adhere to the scleral ridge for easy closure, but also reduces the intraocular content and facilitates the use of intraocular tamponade methods such as combined intra-orbital gas injection[9]. In the last decade, sclerotonyxis has been performed under local anesthesia in patients admitted to our department with acute ACG and persistently high IOP. After the IOP normalizes, stage II treatment is performed based on the patient's condition, and good surgical outcomes have been achieved.

Patients and Methods

Research Participants

The study was approved by the Ethics Committee of Shenzhen Aier Eye Hospital (Approval No. S2021-003-01). The patients/participants provided written informed consent to participate in this paper. Clinical data of 50 eyes from 50 patients with acute ACG with persistently high IOP admitted to our department between January 2012 and January 2022 were analyzed retrospectively. The study participants included 28 females (28 eyes) and 22 males (22 eyes), with an age range of 49-80 years and a mean age of 68.9 ± 7.19 years. After admission, all patients were administered the maximum dose of systemic plus topical anti-glaucoma medication to lower their IOP; those with an IOP of >40 mmHg 24 h after admission underwent sclerotonyxis.

Methods

All surgeries were performed by one surgeon using an operating microscope. After routine disinfection, surgical drape placement, and pad pasting, the lids were opened using an eye speculum. A subconjunctival injection of lidocaine hydrochloride (5 ml: 0.1 g, 0.1-0.2 ml) was administered below the nose. Next, the conjunctiva was penetrated with a 15° corneal paracentesis knife over the anesthesia bubble (misaligned and slightly offset). The anterior sclera was incised at 45° to approximately half the depth at 3 mm posterior to the corneal limbus. The incision was placed parallel to the longitudinal diameter of the eye. Then, the orientation was changed to vertically enter into the central vitreous body to an approximate depth of 10-12 mm. Moreover, the knife handle was rotated, and pressure was applied toward the scleral incision, causing the liquefied vitreous humor oozing. In patients with poor outflow, the blade can be repeatedly rotated to move the eye. At this point, the liquefied or partially liquefied vitreous humor flowed out to IOP Tn. Subsequently, the blade was withdrawn, and the wound was left to self-closing without sutures, followed by topical application of tobramycin dexamethasone ophthalmic ointment. Systemic and topical IOP-lowering medications were applied two hours postoperatively to consolidate the puncture effectiveness.

Different degrees of IOP reduction were noted in the patients. Subsequently, an individualized phase II treatment plan was developed based on corneal transparency, patient's glaucoma episode durations, anterior chamber depth, degree of chamber angle closure by gonioscope and ultrasound biomicroscope (UBM), and fundus changes. The following criteria were considered in developing the treatment plan.

(1) Patients with normal IOP post-sclerotonyxis and within 72 hours of onset, an angle closure of <180°, and concurrent cataract underwent simple cataract phacoemulsification combined with intraocular lens (IOL) implantation. Moreover, patients with a clear crystalline lens with >1.8 mm anterior chamber axis depth, angle closure of <180°, normal pupil recovery, and an uncorrected visual acuity (UCVA) of >0.6 underwent YAG laser peripheral iridectomy.

(2) Patients with an angle closure of >180° and IOP <30 mmHg within 1 week of onset underwent cataract phacoemulsification combined with IOL implantation and goniosynechialysis under a gonioscope.

(3) Patients with a history of recurrent episodes or those admitted more than 1 week after disease onset and those with severe angle closure, adhesions, and significant combined visual impairment, underwent cataract phacoemulsification combined with IOL implantation plus trabeculectomy.

Observation Indicators and Evaluation Criteria

All patients were followed up for 6 months postoperatively.

All patients' UCVA and corrected visual acuity (CVA) were measured using a standard logarithmic visual acuity chart and a phoropter pre- and post-sclerotonyxis and 6 months postoperatively.

Corneal edema and recovery were recorded pre- and post-sclerotonyxis and post-stage II surgery in all patients. Moreover, patients' corneal endothelial cell counts and endothelial loss rates preoperatively, 7 days postoperatively, and 6 months post-stage II surgery were measured with a TOPCON corneal endothelial cell counter (model: SP-3000P).

The IOP at admission, preoperatively, and 1, 2, 3, 5, and 7 days post-sclerotonyxis, the IOP at different periods post-stage II surgery, and the surgical success rates were recorded. The criteria for determining the efficacy were as follows: (1) Complete success: IOP ≤ 21 mmHg without any anti-glaucoma drugs; (2) Conditional success: IOP ≤2l mmHg post administration of additional topical anti-glaucoma drugs; and (3) Failure: IOP >21 mmHg post administration of topical anti-glaucoma drugs.

Changes in anterior chamber depth pre- and post-sclerotonyxis were recorded. The anterior chamber depth and presence of mild edema were measured in patients with corneal transparency using a three-dimensional ocular anterior segment analysis system (Pentacam HR). In patients where the corneal edema affected anterior chamber depth measurement, a UBM (SW-3200L) was used.

Intraoperative and postoperative surgical complications of sclerotonyxis and stage II surgery were recorded.

Statistical Analysis

Data were analyzed using SPSS 23.0 statistical software (IBM Corp., Armonk, NY, USA). Data were expressed as numbers and percentages. The Shapiro-Wilk normality test was performed for measurement data. Normally distributed data were expressed as x±s and subjected to independent samples *t*-test. Moreover, a *p*-value of <0.05 was considered statistically significant.

Results

Among the 50 enrolled patients, 4 underwent YAG laser peripheral iridectomy, 18 underwent simple cataract phacoemulsification combined with IOL implantation, 21 underwent cataract phacoemulsification combined with IOL implantation and goniosynechialysis under a gonioscope, and 7 underwent combined surgery of glaucoma and cataract.

Visual Acuity

Table I shows the patients' best CVA (BCVA) at different times pre- and post-sclerotonyxis and post-stage II surgery.

Six months postoperatively, the visual acuity improved in 48 eyes (96%), and no improvement was observed in 2 eyes (4%). No visual acuity loss occurred in any patient, compared to the visual acuity on admission. Among the two patients who showed no improvement in visual acuity, one had severe ischemia and optic nerve damage due to prolonged preoperative high IOP, resulting in irreversible visual impairment. One patient had preoperative high IOP complicated by central retinal vein occlusion.

Recovery of Corneal Edema and Endothelial Cell Density at Different Times Pre- and Post-Sclerotonyxis and Post the Stage II Surgery

Before sclerotonyxis, 24 eyes had unmeasured corneal endothelial cell counts due to corneal edema. Post-sclerotonyxis, 36, 16, and 4 eyes regained corneal transparency on postoperative days 1, 2, and 3, respectively; furthermore, 5 eyes were given hyperosmotic glucose drops due to prolonged high IOP. Corneal edema resolved and transparency was observed on postoperative day 5. All patients underwent stage II surgery after the corneas regained transparency and stabilized for 1-3 days. The corneal endothelial cell densities were 1,924.7±310.6 and 1,707.1±329.8 before at 7 days post stage II surgery. Moreover, the corneal endothelial cell loss values were 217.6±80.1 and 1,674.1±323.8 preoperatively and 6 months postoperatively, respectively. The corneal endothelial cell loss value was 250.4±82.9.

Table I. Pre-operative and postoperative BCVA follow-up.

	Pre-puncture	Post-puncture	7 days post stage II surgery	6 months post stage II surgery
Vision	0.06±0.1	0.25±0.17	0.41±0.2	0.6±0.3

IOP

The mean IOP of all patients on admission was 68.62±6.09 mmHg. Twenty-four hours after administering the maximum safe dose of medication, the mean IOP reduced to 54.84±7.82 mmHg. On day 1 post-sclerotonyxis, the IOP was <21 mmHg in 36 patients (mean, 21.34±7.81 mmHg). Six patients had an IOP between 21-30 mmHg; after applying slight pressure on the puncture wound, the IOP was reduced to <21 mmHg. Eight patients had IOP between 30-40 mmHg. After repeated puncture wound margin compression using a cotton swab, the IOP was reduced to <21 mmHg. In two of these patients, the IOP elevated after 4 hours, thus needing repeated pressure on the puncture wound to lower the IOP.

The IOP values before drug administration, pre-sclerotonyxis; 24 and 48 hours post-sclerotonyxis; and 3 days, 7 days, 1 month, and 6 months after stage II surgery for all patients are shown in Tables II and III.

Changes in Anterior Chamber Depth (Excluding Corneal Thickness) Pre- and Post-Sclerotonyxis

A statistically significant difference was observed in the mean anterior chamber depths before and after sclerotonyxis (1.75 ± 0.16 mm and 1.84 ± 0.17 mm, respectively) ($t = 12.74$, $p < 0.05$).

Surgical Complications

Suspensory ligament abnormalities in the stage II surgery occurred in 6 patients, and capsular tension ring implantation was performed. No lens dislocation was observed in the follow-ups. A shallow anterior chamber developed in two patients after combined surgery of glaucoma and cataract. Mild choroidal detachment occurred in one eye, whose pupil was then dilated, and a pressure bandage was applied. The choroidal attachment returned to normal within 1 week. No serious complications, such as corneal endothelial decompensation, malignant glaucoma, vitreous or eruptive choroidal hemorrhage, and retinal detachment, occurred in any patient.

Discussion

The Importance of Prompt IOP Control in High IOP States

Primary ACG (PACG) is the most common cause of irreversible blindness in China. It primarily occurs due to the pupillary blockage caused by the lens. According to a survey conducted in Shanghai, China, 3.09% of people >50 years of age are afflicted by PACG; blindness and low visual acuity caused by PACG are more common

Table II. IOP values before drug administration, before puncture, and after puncture (mmHg).

	Before drug administration	Before puncture	24 h after puncture	48 h after puncture
IOP (mmHg)	68.62±6.09	54.84±7.82	21.34±7.81	21.22±7.78

Table III. IOP values at different times after stage II surgery.

	3 days after stage II surgery	7 days after stage II surgery	1 month after stage II surgery	6 months after stage II surgery
IOP (mmHg)	19.58±2.75	18.08±2.47	17.22±2.94	15.94±3.3

At the 6-month follow-up, 42 eyes (84%) attained complete success and 8 eyes (16%) attained conditional success. The details are shown in Table IV. Intraocular pressure (IOP).

Table IV. Pre-operative and postoperative BCVA follow-up.

Treatment schemes	Complete success	Conditional success	Failure
YAG	4	0	0
Cataract phacoemulsification	18	0	0
Cataract phacoemulsification combined with goniosynechialysis	16	5	0
combined surgery of glaucoma and cataract	4	3	0
Cure rate	84%	16%	0

than that caused by open-angle glaucoma[10]. PACG can be classified as acute or chronic according to clinical manifestations, and the majority of PACG patients are elderly. The prevalence of age-related cataracts in individuals >50 years of age is >50%. Thus, PACG is often combined with cataract, and the two eye diseases often interact with each other and accelerate progression[11], which greatly impairs the patients' visual function and quality of life.

In patients with acute ACG with high IOP during major episodes, treatment aims to preserve visual and chamber angle functions. Emergency resuscitation should be performed to control high IOP swiftly, reduce visual function damage, and prevent the formation of permanent adhesions in the chamber angle[12]. Presently, the main goal of acute ACG treatment is to reduce IOP. Despite the administration of systemic and topical medications received after consultation, the IOP does not reduce to a safe level in a significant proportion of patients. Longer duration of high IOP leads to more severe visual acuity and visual field impairment. In the present study, persistent high IOP in two eyes, severe optic nerve ischemia in one eye, and concomitant central retinal vein occlusion in one eye resulted in postoperative visual acuity <0.05 and irreversible impairment of visual function. Moreover, antiglaucoma surgery in a high IOP state leads to relatively more intraoperative and postoperative complications. Ocular congestion is significant in the high IOP state. Thus, the sudden drop in IOP while making an incision in the anterior chamber can cause capillary rupture, resulting in serious complications, such as intraoperative subchoroidal hemorrhage, late postoperative hemorrhage, and choroidal detachment[13].

Safety and Efficacy of Different Treatment Options for Controlling IOP in High IOP States

Presently, anterior chamber sclerotonyxis is the most acceptable and widely used strategy by ophthalmologists for managing persistently high IOP in acute ACG. The procedure involves anterior chamber sclerotonyxis and drainage, IOP reduction, and subsequent stage II antiglaucoma surgery[13-17]. However, due to previous ACG episodes, some patients present with segmental atrophy and loss of elasticity of the iris. The iris tissue can embed in the puncture port during anterior chamber drainage, affecting the sclerotonyxis outcome. Moreover, some patients have an extremely shallow anterior chamber. After anterior chamber drainage, it becomes shallower or can even disappears, aggravating the pupillary blockage and causing a further increase in IOP and corneal endothelial damage. In patients with acute ACG combined with intumescent cataracts, the extremely shallow anterior chamber may cause damage to the intumescent lens during anterior chamber puncture, resulting in iatrogenically induced lens rupture.

According to Gao et al[18], ciliary photocoagulation to first control IOP and further antiglaucoma surgery in stage II, if necessary, is a safe, effective, staged, combined surgical approach in intractable high IOP states. However, ciliary photocoagulation for glaucoma has the following indications: (1) IOP not being reduced despite administration of the maximum safe dose of medication or at least one filtering surgery; (2) In glaucoma absolutum, wherein visual function has been lost, ciliary photocoagulation can be performed to relieve pain and avoid eye removal; (3) Those who are not suitable for other surgeries because of high-risk complications; (4) For patients with uncontrollable or rapidly increasing IOP, such as in malignant glaucoma, laser surgery can be used to temporarily reduce IOP before other surgical treatments. Moreover, postoperative complications are more with ciliary photocoagulation, primarily low IOP, anterior chamber hemorrhage, vision loss, eyeball atrophy, persistent inflammation, intraoperative and postoperative ocular pain, transient high IOP, retinal and choroidal detachment, and corneal transplantation failure[19]. In many primary care hospitals, photocoagulation devices are not available. In acute onset, it is more important to choose an economical and simple IOP-lowering solution; thus, it is difficult to promote this technique in primary care hospitals.

In 1965[20], it was first reported the treatment of typical malignant glaucoma by aspiration of vitreous fluid and fluid/gas injection in the anterior chamber through the flattened portion of the ciliary body. This procedure was modified slightly by replacing the vitreous puncture needle with a 15° corneal puncture knife to artificially create an incision in the eye wall and destroy the vitreous "aqueous sac" created by pupillary blockage. Subsequently, the posterior chamber pressure decreases, the vitreous volume reduces, the pupillary blockage is released, and the anterior chamber depth increases. In the present study, the anterior chamber depth showed a statistically significant difference pre- and post-sclerotonyxis (1.75±0.16 mm and 1.84±0.17 mm, respectively) (t=12.74, p<0.05). Previously reports have advocated vitreous aspiration[21-23], which immediately lowers the IOP, followed by trabeculectomy or combined surgery of glaucoma and cataract. Operating when there is intense congestion in the eye may cause complications, such as severe intraocular inflammatory reaction or choroidal detachment. In the present study, a staged procedure was performed. Stage I comprised sclerotonyxis and drainage to control IOP, stabilize the eye, and ensure potential closure of the puncture port. Postoperatively, if the IOP increased again, it can be lowered by repeated massage of the puncture site. Stage II surgery was performed after the ocular congestion or corneal edema subsided. Despite the rapid and definitive lowering of the IOP, the operation must be performed carefully and aseptically. Moreover, excessive and rapid decreases in the IOP should be avoided, and the liquefied vitreous should be drained slowly to avoid inducing intraoperative fulminant suprachoroidal hemorrhage and postoperative choroidal detachment. The residual vitreous at the puncture site should be thoroughly cleaned postoperatively to avoid vitreous incarceration, which can cause complications such as infectious endophthalmitis, proliferative vitreous retraction, and retinal detachment. After lowering the IOP, the blood supply to the iris is restored. Correspondingly, the iris sphincter regains activity. Moreover, a miotic drug should be promptly applied to release the pupillary blockage, reopen the anterior chamber angle, and provide lasting control of IOP. This method is suitable for patients with acute ACG and persistently high IOP that cannot be relieved by drug therapy alone and has achieved good results, creating favorable conditions for stage II surgery.

Selection Timing and Efficacy of Stage II Surgery After Control of Persistent High IOP Among Patients with Acute ACG

Rational selection of the surgical technique and timing are keys to successful treatment. The Expert Consensus on Diagnosis and Treatment Options for Primary ACG in China (2019) recommends that patients with closed chamber angle, elevated IOP, and pupillary blockage factors should prefer a laser or surgical approach for peripheral iridotomy or resection[24,25]. The Chinese Glaucoma Guidelines (2020), developed by experts from the Glaucoma Group of the Chinese Medical Association Ophthalmology Branch, recommends combined cataract surgery in patients with ACG. Consensus on the choice of surgical approach for PACG combined with cataracts is currently unavailable. Some scholars believe that cataract surgery alone[26,27] is sufficient to reduce IOP. This surgical approach is simple, quick, cost-effective, can release the lens, and has a low surgical risk and few complications; however, it is limited to affected eyes with a cumulative closure of the anterior chamber angle <180° because it is not combined with antiglaucoma surgery. For patients with cataract combined with poor results of combined IOP-lowering medications, cataract extraction combined with IOL implantation and goniosynechialysis under a gonioscope is the first choice of treatment[28]. Postoperative options are determined based on the postoperative IOP: (1) patients with normal IOP levels continue to receive follow-up; (2) patients with poor IOP reduction receive combination medication; and (3) patients with poor response to combination IOP-lowering medication are recommended to undergo combined trabeculectomy. A study[29] recommended anti-glaucoma surgery followed by elective cataract surgery or vice-versa. Advancements in research and technology have led to revolutionary developments in combined surgery of glaucoma and cataract. Currently, ophthalmologists prefer combining glaucoma and cataract surgery (triple surgery)[30]. In the present study, a stage II individualized treatment plan was developed based on the time of glaucoma onset, corneal transparency, anterior chamber depth, lens transparency, degree of chamber angle closure on gonioscope and UBM, and fundus changes in the patients. All patients underwent sclerotonyxis and drainage. Due to the effect of persistent high IOP on the cornea and intraocular tissues, after 48 hours of IOP control, four patients underwent YAG laser peripheral iridectomy, 18 underwent simple cataract phacoemulsification combined with IOL implantation, 21 underwent cataract phacoemulsification combined with IOL implantation and goniosynechialysis under a gonioscope, and 7 underwent combined surgery of glaucoma and cataract, followed by a 6-month follow-up. All patients were evaluated preoperatively to exclude non-pupillary blocking factors. Visual acuity and IOP were closely measured postoperatively. All patients recovered well, achieving the best outcome with minimal damage.

Before sclerotonyxis and drainage, corneal endothelial cell counts in 24 eyes could not be measured due to corneal edema, which was primarily due to the persistently high IOP that disrupts corneal function. High IOP directly impairs the physical barrier function of the corneal endothelium, resulting in altered aqueous humor dynamics wherein water enters the corneal stroma causing corneal edema[31]. Thus, patients with rapidly elevated IOP that cannot be controlled promptly usually have more severe corneal endothelial damage. Post-sclerotonyxis and drainage, the cornea was re-examined after it regained transparency. Corneal endothelial cell counts were measurable in all patients (1,924.7±310.6). Corneal epithelial edema was evident in two eyes during stage II surgery, which may be related to the high preoperative IOP and impaired corneal endothelial function. The corneal epithelium was scraped off intraoperatively because of the edema that affected the surgical operation. Postoperatively, a corneal bandage lens was given to protect the corneal epithelium, hyperosmotic glucose drops, and anti-inflammatory treatment. Corneal endothelial cell counts were 1,707.1 ± 329.8 and 1,674.1 ± 323.8 and corneal endothelial loss values were 217.6 ± 80.1 and 250.4 ± 82.9, at 7 days and 6 months postoperatively, respectively, which are consistent with previous literature[32]. Thus, the corneal endothelium should be protected when performing phacoemulsification, and measures related to low negative pressure, low energy, and "soft shell" techniques should be used. All patients recovered from corneal edema within 1 week after the stage II procedure. Moreover, no corneal endothelial decompensation occurred during the follow-up period.

Conclusions

In conclusion, in patients with acute ACG who are in a persistently high IOP state, sclerotonyxis and drainage can swiftly reduce the IOP, increase anterior chamber depth, and release the pupillary blockage. Thus, it creates a better intraocular maneuvering space and safe IOP for performing stage II surgery, improves the surgical success rate, and reduces complications due to high IOP. All patients in this study achieved good outcomes without any serious complications. This method is an invasive treatment with some operational difficulties; however, it is safe and effective when the surgeon is familiar with ocular anatomy, has mastered the surgical technique, has standardized intraoperative operations, actively and closely observed the postoperative conditions, and has managed various complications symptomatically.

Availability of Data and Materials

The datasets used during the current study are available from the corresponding author on reasonable request.

Conflict of Interest

Authors declare that they have no conflict of interest.

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Ethics Approval

The study was approved by the Ethics Committee of Shenzhen Aier Eye Hospital (Approval No. S2021-003-01).

Informed Consent

The patients/participants provided written informed consent to participate in this paper.

Authors' Contributions

Guarantor of integrity of the entire study: Ligui Zhang; Study concepts: Ligui Zhang; Study design: Yingying Zhang; Definition of intellectual content: Yingying Zhang; Literature research: BeiBei Xu; Clinical studies: Zunxia Hu; Experimental studies: Yingying Zhang, BeiBei Xu, Zunxia Hu; Data acquisition: Yingying Zhang; Data analysis: BeiBei Xu, Zunxia Hu; Manuscript preparation: Yingying Zhang; Manuscript editing: Yingying Zhang, BeiBei Xu, Zunxia Hu; Manuscript review: Ligui Zhang.

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References

1) Zhu M, Yan Y. The surge of acute angle-closure glaucoma during the outbreak of Omicron in a tertiary hospital in Shanghai. Graefes Arch Clin Exp Ophthalmol 2023: 1-3.
2) Nemet A, Nesher R, Almog Y, Assia E. [Bilateral acute angle closure glaucoma following topiramate treatment]. Harefuah 2002; 141: 597-599, 667.
3) Yuan J, Wang Y, Wang P, Ma R. Safety in Treating Primary Acute Angle-closure Glaucoma under High Intraocular Pressure by Compound Trabeculectomy. Pak J Pharm Sci 2016; 29: 2217-2220.
4) Bao YK, Xu BY, Friedman DS, Cho A, Foster PJ, Jiang Y, Porporato N, Pardeshi AA, Jiang Y, Munoz B, Aung T, He M. Biometric Risk Factors for Angle Closure Progression After Laser Peripheral Iridotomy. JAMA Ophthalmol 2023; 141: 516-524.

5) Tian T, Li M, Pan Y, Cai Y, Fang Y. The effect of phacoemulsification plus goniosynechialysis in acute and chronic angle closure patients with extensive goniosynechiae. BMC Ophthalmol 2019; 19: 65.
6) Jin Qi, Song Nianyi, Yu Jianhong, Yang Yonghua. Application of cold needle sclerocentesis in the surgery of Retinal detachment with holes. Journal of Clinical Ophthalmology 2000; 04: 281-282.
7) Samuelsson-Almén M, Nilsson SF, Mäepea O, Bill A. Effects of atrial natriuretic factor (ANF) on intraocular pressure and aqueous humor flow in the cynomolgus monkey. Exp Eye Res 1991; 53: 253-260.
8) Dawes W. Secondary Brain Injury Following Neonatal Intraventricular Hemorrhage: The Role of the Ciliated Ependyma. Front Pediatr 2022; 10: 887606.
9) Hu J, Li H, Zhao Y, Ke Y, Rupenthal ID, Liu H, Ye J, Han X, Yang F, Li W, Lin H, Hou D. Critical Evaluation of Multifunctional Betaxolol Hydrochloride Nanoformulations for Effective Sustained Intraocular Pressure Reduction. Int J Nanomedicine 2022; 17: 5915-5931.
10) He J, Zou H, Tong X, Zhang S, Zhao R, Zhang Y, Zhou W, Tang W, Ge L. [Prevalence of primary glaucoma among adults aged 50 years or above population in Huamu community: a cross-sectional survey in Shanghai, 2011]. Zhonghua Yan Ke Za Zhi 2014; 50: 349-354.
11) Vass C, Menapace R. Surgical strategies in patients with combined cataract and glaucoma. Curr Opin Ophthalmol 2004; 15: 61-66.
12) Ge J, Sun XH, Wang NL, Zhao JL, Wu LL, Chen XM, Wang ZX, Li B. Intraocular pressure lowering efficacy and safety of travoprost 0.004% as a replacement therapy in patients with open angle glaucoma or ocular hypertension. Chin Med J (Engl) 2010; 123: 1417-1421.
13) Riddle MS, DuPont HL, Connor BA. ACG Clinical Guideline: Diagnosis, Treatment, and Prevention of Acute Diarrheal Infections in Adults. Am J Gastroenterol 2016; 111: 602-622.
14) Un Y, Imamoglu S, Tekcan H, Celik G, Ozturk Y, Mangan MS. Factors defining the intraocular pressure-lowering effect of phacoemulsification and laser peripheral iridotomy in patients with primary angle closure: Factors defining IOP lowering effect of PE and LPI in PAC. Lasers Med Sci 2023; 38: 100.
15) Ying S, Coulon SJ, Lidder AK, Labowsky M, Cheng CP, Vinod K, Sidoti PA, Panarelli JF. Choroidal Effusions after Glaucoma Drainage Implant Surgery: Risk Factors and Surgical Management. Ophthalmol Glaucoma 2023; S2589-4196: 00060-1.
16) Jabłońska J, Lewczuk K, Rękas MT. Comparison of Safety and Efficacy of Hydrus and iStent Combined with Phacoemulsyfication in Open Angle Glaucoma Patients: 24-Month Follow-Up. Int J Environ Res Public Health 2023; 20: 4152.
17) Almobarak FA, Alrubean A, Alsarhani WK, Aljenaidel A, Osman EA. Outcomes of Ultrasound Cyclo Plasty in Primary Angle Closure Glaucoma. J Glaucoma 2023; 32: 407-413.
18) Ho YJ, Yeh CH, Lai CC, Huang JC, Chuang LH. Ex-PRESS miniature glaucoma shunt for intractable secondary glaucoma in superior vena cava syndrome - a case report. BMC Ophthalmol 2016; 16: 125.
19) Suelves AM, España-Gregori E, Tembl J, Rohrweck S, Millán JM, Díaz-Llopis M. Doppler ultrasound and giant cell arteritis. Clin Ophthalmol 2010; 4: 1383-1384.
20) Locke JC, Morton WR. Further studies of the viscosity of aspirated human vitreous fluid: with special reference to its use in retinal detachment surgery. Trans Am Ophthalmol Soc 1965; 63: 129-145.
21) Nossair AA, Ewais WA, Ali LS. Retrospective Study of Vitreous Tap Technique Using Needle Aspiration for Management of Shallow Anterior Chamber during Phacoemulsification. J Ophthalmol 2017; 2017: 2801025.
22) Tanaka H, Tanikawa A, Shimada Y, Miyake Y, Mizuguchi T, Horiguchi M. Measurement of the volume of the vitrectomized space during vitrectomy in myopic patients with retinal detachment. Jpn J Ophthalmol 2020; 64: 210-215.
23) Shinkai Y, Yoneda K, Sotozono C. Ex vivo Comparison of Intraocular Pressure Fluctuation during Pars Plana Vitrectomy Performed Using 25- and 27-Gauge Systems. Ophthalmic Res 2022; 65: 210-215.
24) Liang YB, Wang NL, Rong SS, Thomas R. Initial Treatment for Primary Angle-Closure Glaucoma in China. J Glaucoma 2015; 24: 469-473.
25) Timlin H, Butler L, Wright M. The accuracy of the Edinburgh Red Eye Diagnostic Algorithm. Eye (Lond) 2015; 29: 619-624.
26) Chan PP, Li EY, Tsoi K, Kwong YY, Tham CC. Cost-effectiveness of Phacoemulsification Versus Combined Phacotrabeculectomy for Treating Primary Angle Closure Glaucoma. J Glaucoma 2017; 26: 911-922.
27) Brandão-de-Resende C, Alcântara L, Vasconcelos-Santos DV, Diniz-Filho A. Glaucoma and Telemedicine. J Glaucoma 2023; 32: 327-332.
28) Azuara-Blanco A, Burr J, Ramsay C, Cooper D, Foster PJ, Friedman DS, Scotland G, Javanbakht M, Cochrane C, Norrie J. Effectiveness of early lens extraction for the treatment of primary angle-closure glaucoma (EAGLE): a randomised controlled trial. Lancet 2016; 388: 1389-1397.
29) Kaliardas A, Chatziralli I, Katsanos A, Kitsos G. Phacoemulsification versus Phacoemulsification/Trabeculectomy for the Treatment of Primary Open-Angle Glaucoma Coexistent with Cataract: A Comparative Study. Medicina (Kaunas) 2023; 59: 470.
30) Jacobi PC, Dietlein TS, Lüke C, Engels B, Krieglstein GK. Primary phacoemulsification and intraocular lens implantation for acute angle-closure glaucoma. Ophthalmology 2002; 109: 1597-1603.
31) Sugumaran A, Devasena MA, Thomas M, Periyathambi D. A cross sectional study on evaluating the corneal endothelial cell density and central corneal thickness in eyes with primary glaucoma. J Family Med Prim Care 2022; 11: 4650-4654.
32) Yan ZC, Bai YJ, Tian Z, Hu HY, You XH, Lin JX, Liu SR, Zhuo YH, Luo RJ. Anti-proliferation effects of Sirolimus sustained delivery film in rabbit glaucoma filtration surgery. Mol Vis 2011; 17: 2495-2506.