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Clinical Application of Cataract Ultrasonic Emulsification Combined with Atrial Angle Segmentation in the Treatment of Primary Angle-Closure Glaucoma

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Abstract: *Objective:* To evaluate the therapeutic effect of cataract ultrasonic emulsification (PE) combined with atrial angle separation (CSS) for primary angle-closure glaucoma (PACG). *Methods:* 78 patients with PACG admitted to the hospital between October 2021 and October 2023 were selected and grouped by randomized numerical table; 39 cases were counted in the observation group and selected PE combined with CSS surgery; 39 cases were counted in the reference group and selected PE combined with trabeculectomy and the total effective rate, the state of the atrial angle, the clinical indexes, the degree of ocular symptoms, and the complication rate were compared. *Results:* The total effective rate of the observation group was higher than that of the reference group, and the percentage of the wide atrial angle of the atrial angle status was higher than that of the reference group; 3 months after the operation, the logarithm of the minimum angle of resolution (Log MAR) and intraocular pressure of the observation group was lower than that of the reference group, and the central anterior chamber depth (ACD) was greater than that of the reference group; the scores of the degree of ocular symptoms of the observation group were lower than that of the reference group, and the rate of complication was lower than that of the reference group ($P < 0.05$). *Conclusion:* PE combined with CSS surgical treatment for PACG patients can improve the efficacy of treatment, improve the state of the patients' atrial angles, and restore the ocular function indexes. It can alleviate the ocular symptoms as soon as possible and has a high surgical safety.

Keywords: Cataract ultrasonic emulsification; Atrial angle segmentation; Primary closed-angle glaucoma

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1. Introduction

Primary angle-closure glaucoma (PACG) is a type of glaucoma that is highly prevalent in the middle-aged and elderly population, and its etiology is complex, such as lens thickening, which causes the front of the lens to fit tightly on the edge of the pupil, increasing the resistance to the passage of aqueous humor, which in turn elevates the intraocular pressure [1,2]. At this stage, cataract ultrasonic emulsification (PE) combined with

trabeculectomy is a commonly used procedure for this disease, which can effectively control IOP and improve the status of the atrial angle. However, trabeculectomy is prone to complications such as a shallow anterior chamber and has surgical limitations. For this reason, it is necessary to protect the physiological structure of the trabeculae intraoperatively, relieve the stenosis of the anterior chamber and maintain high perfusion pressure to improve the success rate of the surgery. PE combined with CSS surgery is a novel surgical procedure for patients with PACG, which reduces ocular injury, protects the physiological function of the trabecular meshwork, and has higher surgical feasibility [3]. Based on this, 78 patients with PACG were selected in this study to evaluate the surgical outcome of PE combined with CSS.

2. Information and methods

2.1. General information

The 78 cases of PACG patients admitted to the hospital between October 2021 and October 2023 were randomly selected and grouped in a numerical table, 39 cases in the observation group, 23 male patients and 16 female patients; ages ranged from 43 to 74 years old, with a mean value of (51.29 ± 4.87) years old. In the reference group, there were 39 cases, 24 male patients and 15 female patients; ages ranged from 42 to 75 years old, with a mean value of (51.43 ± 4.77) years old. The general information of the two groups was compared with $P > 0.05$.

Inclusion criteria: (1) Diagnosis of PACG confirmed by fundus examination and slit lamp examination; (2) Atrial angle adhesion exceeding 180°, accompanied by lens clouding; (3) Monocular onset; (4) Complete clinical data.

Exclusion criteria: (1) Presence of a history of ocular surgery; (2) Accompanied by severe ocular infection; (3) Accompanied by history of ocular trauma; (4) Presence of impaired consciousness; (5) Written or verbal communication disorders.

2.2. Methods

The preoperative anesthesia method was the same in both groups. Levofloxacin eye drops were used for eye cleaning treatment, with one drop used each time and three times a day. Ten minutes before the operation, oxybuprocaine hydrochloride eye drops were used for ophthalmic local anesthesia.

In the observation group, PE combined with CSS surgery was performed: After anesthesia took effect, a clear corneal incision was made in the direction of 11 o'clock in the operative eye with a length of 3 mm, and an incision was made in the direction of 3 o'clock in the operative corneal limbus on one side with the same length of 3 mm. Sodium hyaluronate gel was injected into the anterior chamber, and a capsular truncation needle was taken to perform a circular capsule tearing operation in the lens capsule area with a diameter of 5–6 mm, hydrolyze the lens cortex and then perform a layered operation. PE treatment was performed with an ultrasonic emulsifying knife consisting of a lunate knife (2.6 mm), a puncture knife (15°), and triangular knife (2.8 mm), and an ultrasonic emulsifier. The lens cortex and lens nucleus were pulverized with the ultrasonic knife and a fractional aspiration operation was performed. Sodium hyaluronate gel was injected for IOL implantation, and then the sodium hyaluronate gel was fully aspirated. Then, the CSS procedure was performed, sodium hyaluronate gel was injected into the region of the atrial angle, the nearby atrial angle was bluntly detached, and moderate pressure was applied to the root of the iris. It was tractioned to the pupillary region, and blunt detachment of all quadrants of the anterior atrial angle was performed at a 360° angle, and the status of atrial angle segmentation was assessed in all directions with an atriascope. If the atrial angle is satisfactorily open and

free of tissue adhesions, the interior of the anterior chamber is adequately cleared of cortical tissue and blood clots, and sodium hyaluronate gel is aspirated. After thorough cleaning within the anterior chamber, the water closes the incision. Check for any abnormalities such as incisional oozing and apply a moderate amount of tobramycin dexamethasone ophthalmic ointment in the conjunctival sac, take gauze with moderate pressure and wrap it.

The reference group was treated with PE combined with trabeculectomy: PE surgical therapy was performed as above. After the successful implantation of the IOL, moderate traction was applied to the superior rectus muscle, and the corneal limbus was used as the base during conjunctival flap fabrication. At the same time, the bulbar conjunctiva was separated and cauterized to stop hemorrhage. The scleral flap was then created and separated to reach about 1 mm inside the clear corneal area, and about 1/3 of the tissue near the iris and trabecular tissue was removed. The iris pigment was flushed with the blood clot in the area, interrupted sutures were applied to the conjunctival flap as well as the scleral flap, and an appropriate amount of sterile air bubbles was taken and injected into the lateral incision to restore the anterior chamber with a watertight opening. The follow-up treatment method is the same as that of the observation group.

2.3. Observation indexes

(1) Atrial angle status: 3 months after the operation, the atrial angle status was evaluated by Seheie's classification method:
   (a) Wide atrial angle: Atrial angle structure was visible in the *in-situ* state, and the iris was relatively flat all around;
   (b) Grade I narrow atrial angle: The atrial angle was narrowed, and the structure of the atrial angle was visible in the atrial angle mirror and the ciliary body bands;
   (c) Grade II narrow atrial angle: The atrial angle mirror was narrowed, no ciliary body bands were visible, and the scleral protrusion was visible;
   (d) Grade III narrow atrial angle: The atrial angle was obviously narrowed, the line of sight exceeded the iris part, and the scleral prominence and the posterior half of the trabeculae are not seen;
   (e) Grade IV narrow atrial angle: The atrial angle is severely narrowed, and the outer atrial angle in the region of the anterior boundary is visible.

(2) Clinical indicators: Before and 3 months after surgery, the best-corrected visual acuity was tested with the International Visual Acuity Scale (IVS) and converted to Log MAR; the intraocular pressure (IOP) level was evaluated using a tonometer at the same time period; and the ACD was measured using an atrial microscope at the same time period.

(3) Degree of ocular symptoms: During the same time period, the International Standardized Ocular Surface Disease Index Scale (OSDI) was issued. It contained ocular symptoms (counting 3 items), environmental triggers (counting 3 items), and visual function (counting 6 items), with each item having a score between 0 and 4 and the degree of symptomaticness being scored positively.

(4) Complications: Corneal astigmatism, shallow anterior chamber, macular edema, iris damage, and anterior chamber blood accumulation.

2.4. Efficacy evaluation criteria

(1) Significant efficacy: Eye-related symptoms completely disappeared, stopped using IOP-lowering drugs, and the IOP level was measured at 7–20 mmHg;

(2) Preliminary efficacy: Eye-related symptoms improved, continued taking IOP-lowering drugs, and the

IOP level was measured at 21–30 mmHg;

(3) No efficacy: No improvement in the eye-related symptoms, continued taking the drugs, and the IOP level was more than 30 mmHg.

2.5. Statistical analysis

The data were processed by SPSS 28.0 software, and the measurement data were expressed as mean ± standard deviation (SD), using *t*-value comparison and test. The count data were expressed as [*n*/%], using χ^2 value comparison and test, and if the statistics were significant, then $P < 0.05$.

3. Results

3.1. Comparison of the total effective rate of the two groups

The total effective rate of the observation group was higher than that of the reference group ($P < 0.05$), as shown in **Table 1**.

Table 1. Comparison of the total effective rate of the two groups [*n*/%]

Group	Significant efficacy	Preliminary efficacy	No efficacy	Total effective
Observation group ($n = 39$)	20	17	2	94.87 (37/39)
Reference group (n = 39)	15	15	9	76.92 (30/39)
χ^2				5.186
P				0.023

3.2. Comparison of atrial angle status between the two groups

At 3 months postoperatively, the percentage of wide atrial angle in the observation group was higher than that in the reference group ($P < 0.05$), as shown in **Table 2**.

Table 2. Comparison of atrial angle status between the two groups [*n*/%]

Group	Wide atrial angle	Grade I narrow atrial angle	Grade II narrow atrial angle	Grade III narrow atrial angle	Grade IV narrow atrial angle
Observation group ($n = 39$)	31 (79.49)	4 (10.26)	3 (7.69)	1 (2.56)	0
Reference group (n = 39)	22 (56.41)	9 (23.08)	5 (12.82)	2 (5.13)	1 (2.56)
χ^2	4.768	2.308	0.557	0.347	1.013
P	0.029	0.129	0.455	0.556	0.314

3.3. Comparison of clinical indicators between the two groups

Preoperatively, the clinical indexes of the two groups were compared, and there was no difference ($P > 0.05$). Three months after the operation, the clinical indicators of the observation group were better than those of the reference group ($P < 0.05$). See **Table 3**.

Table 3. Comparison of clinical indexes between the two groups (mean ± SD)

Group	Log MAR		Intraocular pressure (mmHg)		ACD (mm)	
	Pre-operative	Post-operative	Pre-operative	Post-operative	Pre-operative	Post-operative
Observation group (n = 39)	0.71 ± 0.18	0.31 ± 0.14	39.18 ± 4.32	13.24 ± 1.84	1.65 ± 0.32	3.06 ± 0.41
Reference group (n = 39)	0.73 ± 0.20	0.39 ± 0.17	39.22 ± 4.28	18.42 ± 1.90	1.68 ± 0.33	2.68 ± 0.38
t	0.464	2.269	0.041	12.231	0.408	4.245
P	0.644	0.026	0.967	0.000	0.685	0.000

3.4. Comparison of the degree of ocular symptoms between the two groups

Preoperatively, the ocular symptom degree scores of the two groups were compared, and there was no difference ($P > 0.05$). Three months after the operation, the ocular symptom degree scores of the observation group were lower than those of the reference group ($P < 0.05$). See **Table 4**.

Table 4. Comparison of the degree of ocular symptoms between the two groups (mean ± SD)

Grouping	Eye symptoms		Environmental triggers		Visual function	
	Pre-operative	Post-operative	Pre-operative	Post-operative	Pre-operative	Post-operative
Observation group (n = 39)	9.18 ± 1.36	4.35 ± 0.44	9.04 ± 1.22	4.49 ± 0.33	18.35 ± 2.37	10.15 ± 1.56
Reference group (n = 39)	9.19 ± 1.38	5.12 ± 0.49	9.02 ± 1.28	5.06 ± 0.37	18.39 ± 2.33	13.52 ± 1.61
t	0.032	7.302	0.071	7.180	0.075	9.388
P	0.974	0.000	0.944	0.000	0.940	0.000

3.5. Comparison of the complication rate between the two groups

The complication rate of the observation group was lower than that of the reference group ($P < 0.05$). See **Table 5**.

Table 5. Comparison of complication rate between the two groups [n/%]

Group	Corneal astigmatism	Shallow anterior chamber	Macular edema	Iris damage	Anterior chamber hematoma	Incidence
Observation group (n = 39)	1	1	0	0	0	5.13 (2/39)
Reference group (n = 39)	3	2	1	1	1	20.51 (8/39)
χ^2						4.129
P						0.042

4. Discussion

The pathogenesis of PACG is related to mental trauma, prolonged emotional disorders, ocular overuse, etc. The disease manifests itself in the form of closure of the atrial angle, elevated intraocular pressure and poor aqueous humor outflow, which can lead to clouding of the lens, which can then be combined with cataract [4]. The conventional surgical procedure for this disease is PE combined with trabeculectomy, in which PE surgery can

be performed to aspirate the lens and then implant an artificial lens, which can move the iris septum posteriorly and improve the performance of the pupillary block [5,6]. Trabeculectomy can remove the trabecular tissue, reduce IOP and open the atrial angle. However, the above procedures can lead to complications such as blood seepage from the incision, making the anterior chamber disappear, or causing blood accumulation in the anterior chamber. In severe cases, malignant glaucoma can be induced, which directly affects the prognosis of the surgery [7]. CSS surgery does not need to resect the trabecular tissue, and it can bluntly detach the narrow-angle of the atrium to effectively deepen the depth of the anterior chamber, which improves the degree of stenosis of the anterior chamber and relieves the pupillary block manifestation. Based on this, the aqueous humor can be smoothly outflowed, the waterproof circulatory status can be significantly improved, the intraocular pressure level can be reduced, and its surgical efficacy is better [8,9].

The results showed that the total effective rate of the observation group was higher than that of the reference group, and the percentage of the wide atrial angle of the atrial angle status was higher than that of the reference group. 3 months after the operation, the clinical indexes of the observation group were better than that of the reference group, the scores of the degree of ocular symptoms were lower than that of the reference group, and the rate of complications was lower than that of the reference group ($P < 0.05$). The reason is that PE combined with CSS surgery can reset the iris, effectively open the atrial angle, increase the depth of the anterior chamber, and promote the smooth outflow of aqueous humor, so the level of intraocular pressure is lower [10]. After aspiration of the lens, the original space of the cataract can be opened, and the atrial angle's anatomical characteristics can be restored to improve the atrial angle's status. OSDI is a commonly used evaluation scale for patients with PACG, which assesses the ocular symptoms. PE combined with CSS surgery is less invasive, which reduces the chances of postoperative complications and significantly improves ocular-related symptoms. Therefore, the scores of each of the OSDI are lower [11]. In terms of complications, the CSS procedure is simpler and less likely to produce filter bubble scarring, thus reducing complications such as macular edema and iris damage.

5. Conclusion

In conclusion, PE combined with CSS surgery for patients with PACG has a high efficacy, improves the atrial angle status and ocular symptoms, and has a high surgical safety.

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