

Single-pass four-throw pupilloplasty for angle-closure glaucoma

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Angle-closure glaucoma is characterized by appositional or synechial closure of the anterior chamber angle with glaucomatous field defects that may or may not be associated with a pupillary block. Surgical pupilloplasty with single-pass four-throw technique helps to alleviate the appositional closure along with the breakage of peripheral anterior synechia, thereby increasing the aqueous outflow and decreasing intraocular pressure.

Key words: Angle-closure glaucoma, peripheral anterior synechia, pupilloplasty, single-pass 4-throw, SFT

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Angle-closure glaucoma (ACG) is a major cause of blindness worldwide^[1] and is characterized by increased intraocular pressure (IOP) due to appositional or synechial angle closure associated with visual field defects. Apart from medical therapy, various surgical procedures have been described that constitute the mainstay of treatment for ACG and help to mitigate its progression.

Single-pass four-throw (SFT) technique^[2] for performing pupilloplasty facilitates the reconstruction of pupil shape and size following pupillary deformation. Surgical pupilloplasty has been reported for the management of secondary ACG due to trauma.^[3] For phakic eyes with ACG, cataract extraction has been proven to be beneficial, and its role has been documented.^[4] In this adoption of SFT for ACG, we report performing SFT following cataract surgery in phakic eyes that documented ACG with peripheral anterior synechia (PAS) in the preoperative period. The authors also report the feasibility of performing SFT for selected cases of ACG that have a synechial closure of the anterior chamber drainage angle followed by breakage of the PAS and lowering of the IOP postoperatively.

Surgical Technique

The surgical technique of SFT has been described for pupil reconstruction and has been further modified for application in cases of ACG. The procedure is performed under peribulbar anesthesia, and supplemental anesthesia can be administered as necessary.

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For cases with ACG [Fig. 1a], the pupillary margin is grasped with an end-opening forceps and pulled toward the center of the pupil. The pupillary stretch is performed every 2-clock hour around the entire pupillary margin [Fig. 1b]. The 10-0 suture attached to the long arm of the needle is passed through the proximal iris tissue while the end-opening forceps grasp it [Fig. 1c]. The 10-0 needle is then passed through the distal iris tissue, and the tip of the 10-0 needle is then docked into the barrel of the 26-gauge needle introduced from the paracentesis incision from the opposite side [Fig. 1d]. The 26-gauge needle is withdrawn from the anterior chamber, and this draws along with it the 10-0 needle out of the eye [Fig. 1e]. A Sinskey's hook is passed through the paracentesis incision, and the loop of the suture is grasped with an end-opening forceps and is withdrawn from the eye [Fig. 1f]. The suture end is passed through the loop 4 times [Fig. 2a] and both the suture ends are then pulled from either side of the eye [Fig. 2b]. The approximating loop slides inside the eye and brings both the iris leaflets together. The suture ends are then cut with the microscissors [Fig. 2c and Video 1]. The procedure of SFT is repeated in the opposite quadrant, and a minimum of 4-point traction is achieved [Fig. 2d-f].

Results

Overall, five eyes of five patients underwent SFT pupilloplasty for ACG. The demographics of the patients have been given

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in Table 1. The mean age of the patients was 60.4 ± 18.8 years, and two out of five had failed Laser peripheral (LPI). All cases had a minimum follow-up period of 6 months (range 6–8 months). There was a significant change in the uncorrected visual acuity ($P < 0.05$) and best-corrected visual acuity ($P < 0.05$) following SFT. There was a significant

reduction in the IOP from preoperative to postoperative period ($P = 0.043$), and the mean IOP at 1 month was 14.8 ± 4.6 mmHg. Four eyes maintained IOP < 18 mmHg, while one eye had a postoperative raise at 2 weeks, which was controlled by one antiglaucoma medication. The anterior chamber angle assessment, anterior chamber depth (ACD)

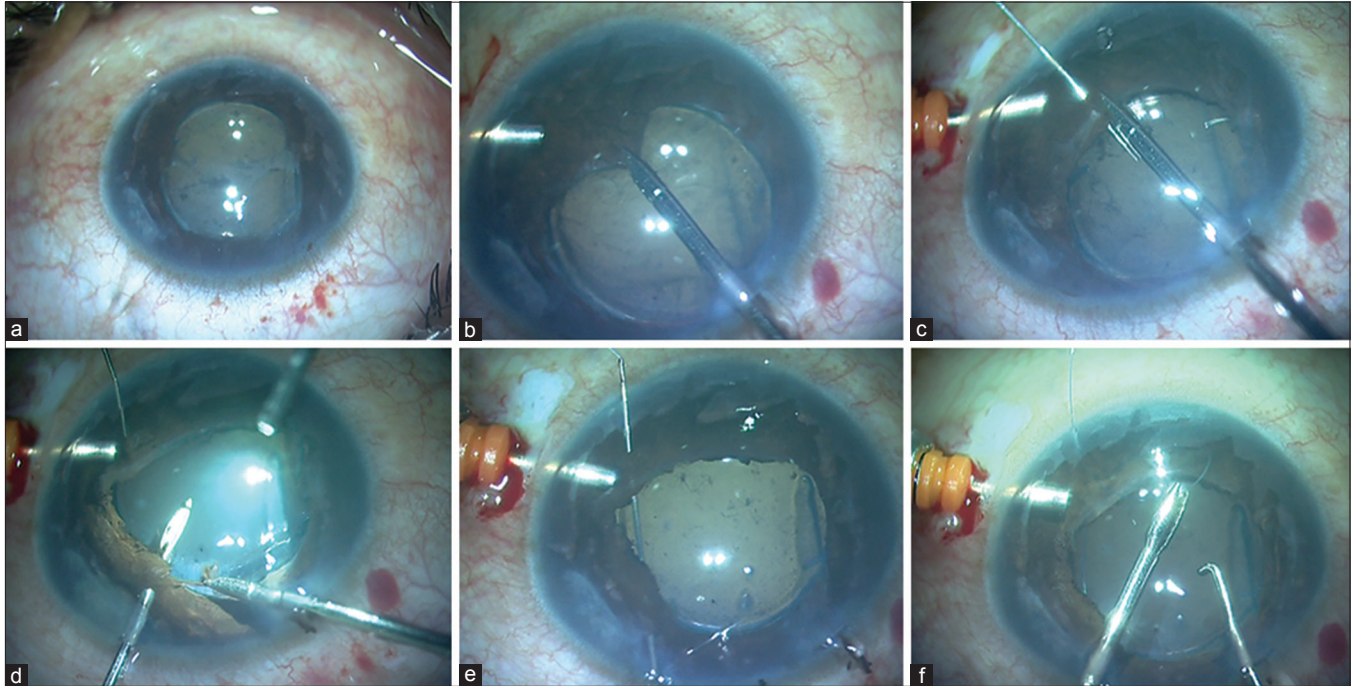


Figure 1: Single-pass 4-throw pupilloplasty technique for angle-closure glaucoma. (a) Cataract extraction done in a case of angle-closure glaucoma. (b) Pupillary stretching. (c) A 10-0 needle passed from proximal iris leaflet. (d) A 26-gauge needle introduced from opposite side through paracentesis incision. (e) The 10-0 needle is docked into 26-gauge needle. (f) Suture loop withdrawn

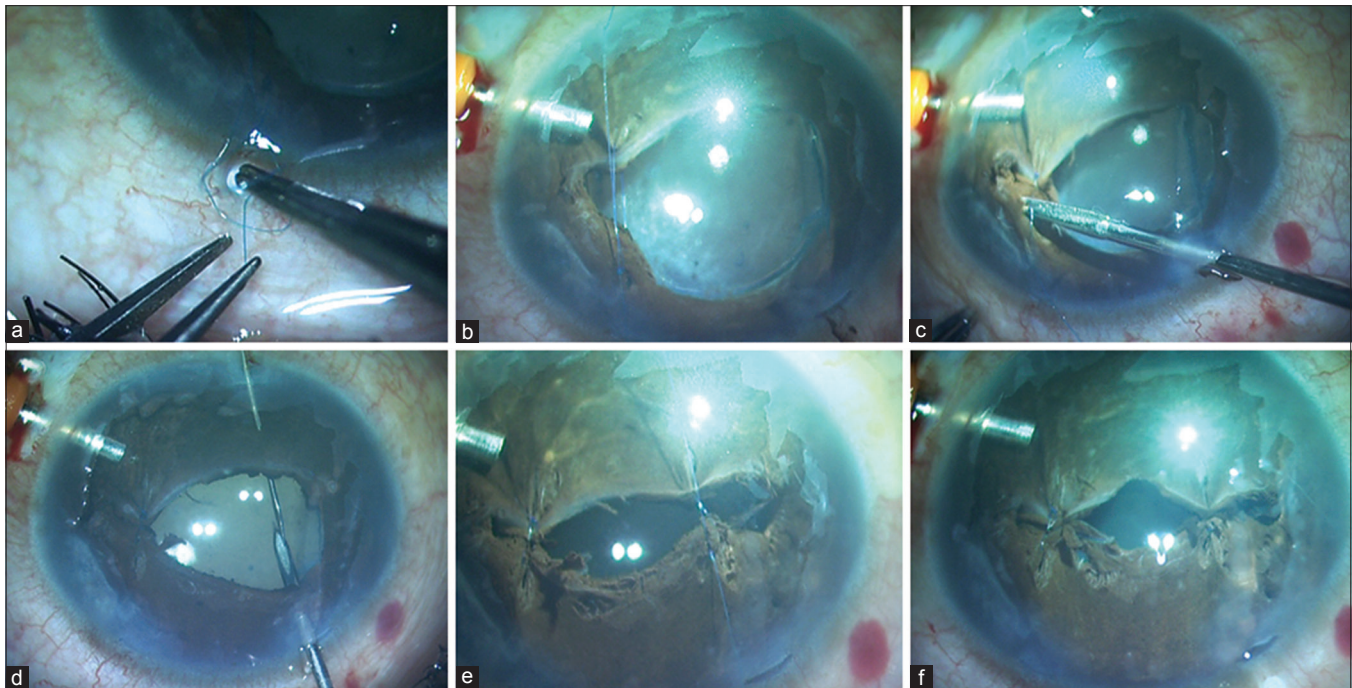


Figure 2: Single-pass 4-throw pupilloplasty technique for angle-closure glaucoma. (a) Suture end is passed through the loop and 4 throws are taken. (b) Both suture ends are pulled. (c) Knot cut with microscissors. (d) Single-pass four-throw being performed in other quadrant. (e) Both suture ends pulled. (f) Pupillary stretch with 4-point traction

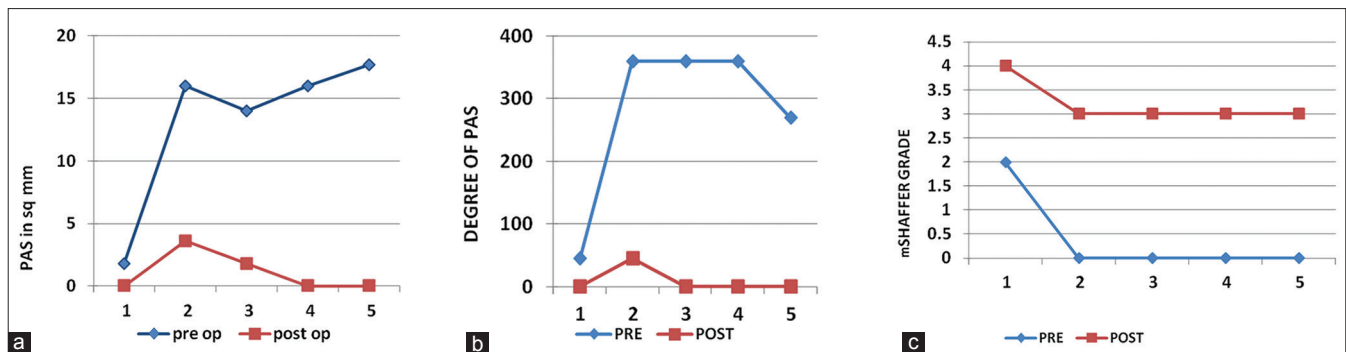


Figure 3: Graphic representation of parameters for all the cases in preoperative and postoperative period. (a) Graph demonstrating area of posterior anterior synechia in the preoperative and postoperative period. (b) Graph demonstrating the degree of peripheral anterior synechia in the pre- and post-operative period. (c) Graph demonstrating the gonioscopy angle grading in pre- and post-operative period

measurement, and quantification of the degree of PAS were determined by screening all axes of the angles using anterior segment optical coherence tomography (AS-OCT). There was a significant reduction in the degrees of PAS and the area of PAS ($P = 0.043$) that was assessed by gonioscopy angle digital photography analysis [Image J software; Fig. 3]. Postoperatively, there was a significant deepening of ACD ($P = 0.043$). There was a significant clinical opening of the angle detected on gonioscopy from preoperative to postoperative period ($P = 0.034$) and a Goldmann 3-mirror lens was used to perform gonioscopy and modified Shaffer's grade was assigned for each quadrant. In a case of Urrets-Zavalía (UZ) syndrome, cut through of the iris tissue during the passage of needle was observed due to associated iris atrophic patches. The needle had to be passed very carefully in this case avoiding all the areas of iris thinning to prevent any further chaffing of the iris tissue. No other major complication was observed in any of the other cases.

Discussion

ACG may be of a primary or a secondary type, with or without the association of pupillary block mechanism. Angle crowding is a commonly associated feature with ACG, and in prolonged cases, it leads to the formation of PAS, and the extent of the presence of PAS correlates with the level of IOP. Various procedures have been described for breakage of PAS, but the role of surgical pupilloplasty has never been widely adopted as a modality of treatment for ACG.

During the procedure, it is essential to involve a greater area of iris tissue into the loop or knot of pupilloplasty as the amount of tissue involved is directly proportional to the amount of traction exerted to break the PAS. In cases with more than 270° synechia, we recommend performing a 6-point traction that translates into making three passes with SFT for achieving pupillary knots. In cases with $<270^\circ$ of PAS, a 4-point traction suffices well to break all the synechia and has a trabecular meshwork function restored. In addition to this, the pupillary stretch that is performed also helps to alleviate and loosen the synechias, and the pupilloplasty procedure ensures that the pull exerted on the PAS is sustained.

LPI iridotomy is the treatment of choice in cases with primary ACG (PACG) associated with pupillary block. However, often the formation of PAS continues even after successful LPI has been performed.^[5-7] Argon LPI

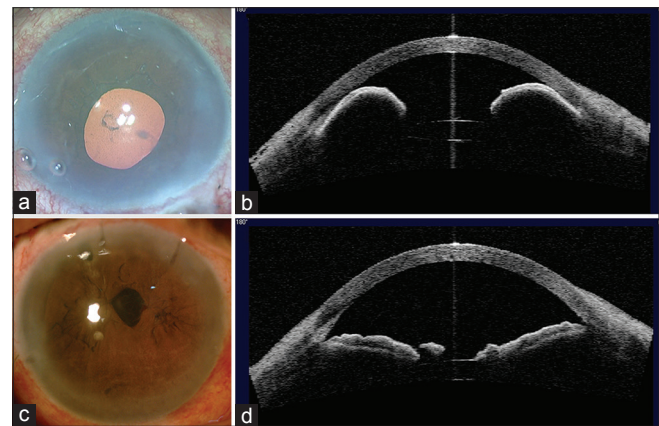


Figure 4: Clinical images with anterior segment optical coherence tomography. (a) A case of angle-closure glaucoma with cataract extraction. (b) Anterior segment optical coherence tomography of angle-closure glaucoma case after cataract extraction. (c) Clinical image of the same case after single-pass four-throw procedure. (d) Anterior segment optical coherence tomography shows open angles with breakage of peripheral anterior synechia and a flat iris plane

iridoplasty (ALPI) is often considered that acts by pulling the iris tissue from the periphery and helps to open the angles and relieve the appositional closure.^[8] Performing an ALPI necessitates the requirement of a laser facility and it often needs to be re-performed, whereas performing a surgical pupilloplasty exerts traction by constantly pulling the peripheral iris.

In patients with plateau iris syndrome (Case 1), the LPI seldom works, and ALPI is advised. Postoperatively for Case 1, following SFT, there was a marked decrease in IOP with opening of the angles and a marked decrease in the degree and area of PAS. In Case 2, UZ syndrome was present with a mydriatic nonresponsive pupil following 1 month after combined surgery of cataract and penetrating keratoplasty performed for keratoconus. The patient had 360° synechia that opened following an SFT procedure. This served the dual purpose of breaking the PAS and also reshaping the pupil size and preventing the photophobia and glare that is commonly associated. Although there were patches of iris atrophy, the site for SFT was chosen accordingly so that the needle could easily pass through the iris tissue without any effective cut through.

Table 1: Demographics of the patients who underwent single-pass four-throw pupilloplasty for angle-closure glaucoma

Cases	Eye/ age/ sex	Primary diagnosis	IOP	Degree of PAS		Area of PAS mm ²	Gonioscopy angle grade		Degree of angle closure (0°-360°)
				Preoperative	Postoperative		Preoperative	Postoperative	
1	OD/65/ female	Plateau iris syndrome	16	10	0	1.8	2	4	45
2	OS/39/ female	Urrets-Zavalla syndrome	10	360	115	16	0	3	360
3	OD/43/ male	Secondary angle closure with silicone oil in vitreous	20*	270	15	14	0	3	360
4	OD/72/ female	PACG with failed LPI	18	360	0	16	0	3	360
5	OS/83/ female	PACG with failed LPI	10	270	0	14	0	4	360

*On antiglaucoma medication. PACG: Primary angle-closure glaucoma, PAS: Peripheral anterior synechiae, LPI: Laser peripheral iridotomy, IOP: Intraocular pressure, OD: Right eye, OS: Left eye

Case 3 had secondary ACG due to the long-standing presence of silicon oil in the eye from a previous retinal detachment surgery. Removal of silicon oil with SFT was performed with effective opening of angles on AS-OCT and gonioscopy. Case 4 and 5 had PACG where LPI had been done; irrespective of that, the angle crowding progressed and led to the development of PAS. SFT relieved the 360° angle closure with complete breakage of PAS. Simultaneous cataract extraction was performed in Case 1 as the patient had associated nuclear sclerosis whereas stand-alone SFT was performed in Case 2, 4, and 5 as these eyes were pseudophakic.

Goniosynechiolysis (GSL) has been described as a treatment for breaking the PAS, but the beneficial effect of this procedure is maximized when performed with cataract surgery.^[9,10] Removal of the natural lens and its replacement with a thinner intraocular lens (IOL) create space in the anterior chamber thereby discouraging the further formation of PAS. It has also been demonstrated that when lens is not removed and the angle is not fully open (Grade 4), the iris creeps backup and retracts the effect of GSL. Higher success

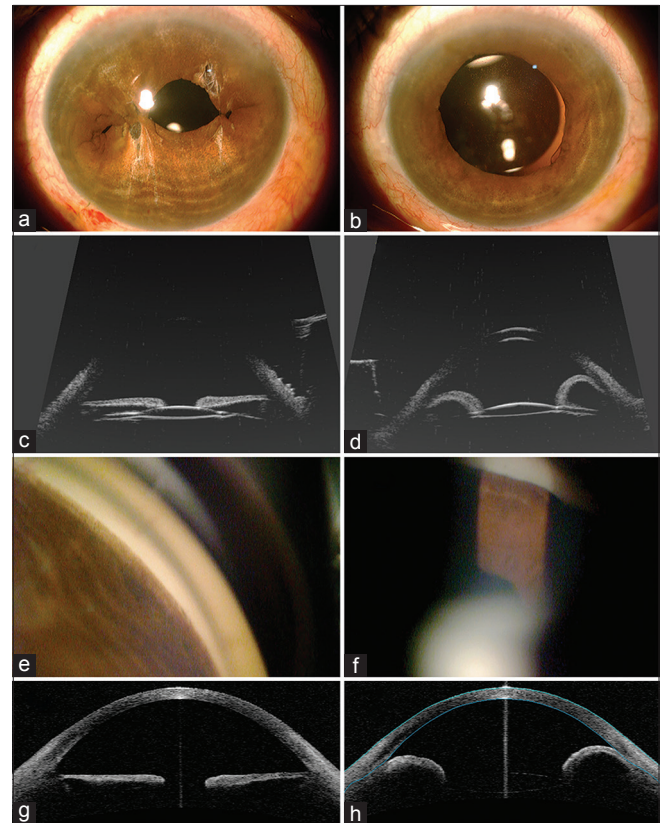


Figure 5: Comparative images of both eyes of a case of angle-closure glaucoma with plateau iris syndrome and cataract extraction (left column = left eye with single-pass four-throw; right column = right eye with no single-pass four-throw). (a) Postoperative image of the left eye with single-pass four-throw and cataract extraction. (b) Postoperative image of the right eye with only cataract extraction done. (c) Ultrasound biomicroscopy denotes open angles with flat iris tissue. (d) Ultrasound biomicroscopy denotes iris bombe with peripheral anterior synechia. (e) Gonioscopy shows open angles. (f) Gonioscopy shows closed angles. (g) Anterior segment optical coherence tomography shows open angles. (h) Anterior segment optical coherence tomography shows angle closure with iris bombe

rate has been reported after lens removal, performing GSL, and putting the patient on pilocarpine eye drops to prevent the iris from retracting back in the angle. SFT pupilloplasty overcomes all these factors and serves an effective way in breaking the PAS, and when performed in conjunction with lens removal, it serves as a method to resolve the raised IOP by breaking the PAS and opening the anterior chamber angle and also preventing the iris from falling back into the angle [Fig. 4]. Nevertheless, SFT can also be performed in pseudophakic eyes that demonstrate a chronic angle closure. The authors do not recommend performing SFT for neovascular, malignant, inflammatory, or other forms of secondary angle closure where the primary cause is yet not identified or treated.

Performing an iris encircage in refractory angle closure along with GSL has been reported, but it is documented for addressing the atonic pupil and preventing the glare and photophobia from the IOL optic edges.^[11] To the best of our knowledge, this is the first study with clinical implications that documents the application of surgical pupilloplasty for cases with ACG. Performing a surgical pupilloplasty mioses the pupil, but with the SFT procedure, it has been documented that pharmacological pupil mydriasis can be achieved post-SFT that can aid in adequate fundus visualization and also help in monitoring glaucoma progression.^[12] The authors report performing SFT for cases with plateau iris syndrome [Fig. 5], primary ACG with failed LPI, chronic ACG, and cases with UZ syndrome with favorable results.

Conclusion

To conclude, SFT serves as an effective modality wherein surgical pupilloplasty combined with cataract extraction [Fig. 5] can be considered as a primary method for treatment of selected cases of ACG with PAS. However, long-term studies are essential to assess the feasibility of the surgical procedure.

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Conflicts of interest

There are no conflicts of interest.

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