• Brief Report •

Thirty-gauge needle-guided purse-string suture pupilloplasty: a new technique

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Abstract

● **AIM:** To observe the clinical outcomes of 30-gauge (G) needle-guided 10-0 prolene suture purse-string pupilloplasty for atonic pupil management.

● **METHODS:** Eight patients with atonic pupils who underwent suture purse-string pupilloplasty were retrospectively analyzed. Preoperative data and at least 6mo of postoperative data were collected from all the patients.

● **RESULTS:** The corrected distance visual acuity (CDVA) before and after surgery was 0.58±0.22 and 0.20±0.10 logMAR, respectively (P=0.002). The pre- and postoperative pupil size was 7.38±0.88 and 3.09±0.71 mm (P=0.000), respectively. The corneal endothelial cell count was 2841±176/mm^2 before and 2692±143/mm^2 after surgery (P=0.000). No intraoperative or postoperative complications were reported. During the follow-up period of at least 6mo, all treated pupils were centered and generally or nearly round. Furthermore, the patients did not exhibit photophobia, glare, or diplopia.

● **CONCLUSION:** This technique is a simple and effective method for pupil reduction.

● **KEYWORDS:** purse-string suture; iris reconstruction; iris cerclage; atonic pupil; needle-guided suture
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INTRODUCTION

An atonic pupil is caused by damage to the iris sphincter, causing the pupil to become fixed. It most commonly occurs with ocular trauma but is also seen with acute primary angle closure (APAC)[1] and after cataract surgery[2]. The patient may experience symptoms such as glare, photophobia, and diplopia, which can be particularly pronounced in an eye with an intraocular lens (IOL), where aberrations are produced by the border of the IOL and/or the anterior capsule. Moreover, higher-order aberrations are closely associated with pupil size, and mydriasis reduces the quality of vision[3].

Iris reconstruction has been performed to repair defects and anomalies of the iris. In 1976, McCannel[4] first reported direct suturing of the iris, and since then many researchers have made improvements to the McCannel suturing technique. In 1994, Siepser[5] reported a sliding-knot technique. In 2017, a single-pass four-throw pupilloplasty technique was reported[6], which is actively used in practice currently[7-10]. The purpose of improving these techniques is to achieve better results and make the operation easier for the surgeon. Usually, the atonic pupil does not present defective iris tissue but local or peripheral atrophy and thinning, especially near the pupil margin. Thinning of the iris tissue makes it very fragile, which makes surgical repair technically challenging. These techniques or their modifications are used for pupillary reduction[11-21]. The pupil is not round in appearance and resembles the shape of a "cat's eye" with an obtuse angle at the knot and an accumulation of iris tissue folds. Despite the surgical correction, pupil centering may be insufficient, and improvement of visual acuity may be limited. Some researchers have used a long curved needle to perform iris cerclage (continuous intraocular suture)[22-25], achieving a better postoperative pupil appearance with a nearly round pupil. However, this usually requires more than three incisions in the corneal margin and a needle holder to control the long curved needle, which may lead to twisting of the needle, excessive traction of the iris tissue, and potential iridodialysis and hemorrhage. Furthermore, the needles must pass completely through the anterior chamber several times, which increases the risk of damage to the intraocular tissues. In 2021, Safran *et al*[26] reported an iris reconstruction technique using needle-guided sutures based on the sewing machine technique, which can be used alone or in combination with other techniques to repair different types of iris defects. The bevel of the suture-bearing needle tip must pass completely

through the iris tissue to expose the suture for intraocular forceps clamping. Excessive anterior chamber manipulation during this process could increase the risk of hemorrhage and peripheral tissue damage.

Therefore, a 30-gauge (G) needle-guided 10-0 prolene purse-string suture pupilloplasty was proposed as a new technique for atonic pupils. This technique requires only three small incisions in the corneal margin that form an isosceles triangle, with the 30-G needle passing between the three incisions, and the sutures were manipulated extraocularly to minimize excessive manipulation of the anterior chamber. To our knowledge, this technique has never been used for purse-string suturing of atonic pupils.

PARTICIPANTS AND METHODS

Ethical Approval The study was conducted in accordance with the principles of the Declaration of Helsinki and approved by the Institutional Review Board of Liyang Hospital of Chinese Medicine (2021LY-03-02-01). All surgical procedures were carried out by the same experienced physician. After a thorough conversation with the surgeon about the pros and drawbacks of all potential operations, the patients decided the method of surgery and signed the consent form before operation.

Subjects and Examination This retrospective study included eight patients who underwent purse-string suturing for atonic pupils at Liyang Hospital of Chinese Medicine between March 2021 and December 2022. Patients with an intact iris without defects and no tears in the pupillary margin were included in the study, regardless of the presence of IOL or previous vitreous surgery. Patients with iris defects or extensive iridodialysis requiring suturing were excluded. The following data were recorded: 1) baseline characteristics; 2) preoperative measurements, including pupil size, corrected distance visual acuity (CDVA), intraocular pressure (IOP), funduscopic examination, ocular ultrasound (US), fundus photography, and macular optical coherence tomography (OCT); 3) intraoperative measurements, including surgical duration and complications; 4) postoperative measurements at 1wk, 1, 3, and 6mo, including pupil size, CDVA, IOP, corneal endothelial cell count (CECC), funduscopic examination, ocular US, and macular OCT. The patients were interviewed regarding their symptoms, including photophobia, glare, and diplopia.

Surgical Procedure The following materials were needed for the pupillary purse-string suturing technique: 30-G needle (0.3 mm×13 mm), 10-0 prolene suture, 1-mL syringe, 23-G retinal forceps, and retinal scissors. All surgeries were performed by the same surgeon under retrobulbar anesthesia. The detailed procedure was illustrated in Figure 1 and Supplementary Video 1.

In this technique, a 1-mL syringe was attached to a 30-G needle, the end of the needle was bent into an arc, the tip of the needle was beveled to face upward, and a 10-0 prolene suture was threaded into the needle. A 2.8-mm corneal margin incision was made at the 12 o'clock position, and this incision could be used to complete the lens surgery. Moreover, 1.0 to 1.2-mm corneal margin incisions were made at the 4 o'clock and 8 o'clock positions. The anterior chamber was injected with a viscoelastic agent or continuously irrigated. The left hand held the needle at 12 o'clock corneal incision to enter the anterior chamber, and the right hand held retinal forceps at 8 o'clock corneal incision to enter the anterior chamber. The needle was used to penetrate the iris 4-6 times using the retinal forceps, and the retinal forceps were used to withdraw the needle. The suture was pulled through, and the needle was withdrawn from the anterior chamber. The suture pulled out from the 8 o'clock position was threaded again into the 30-G needle. The needle was held in the right hand as it entered the anterior chamber and traveled from the 8 o'clock position towards the 4 o'clock position. Both hands were used to penetrate the iris 4-6 times before withdrawing the needle and pulling the suture out from the 4 o'clock incision, and then the needle was withdrawn. Alternatively, the needle can be threaded directly through the chamber angle, and the suture can be pulled out by inserting intraocular forceps into the eye. The suture was threaded into the needle for the third time. The needle was held in the left hand as it entered the anterior chamber and traveled from the 4 o'clock position toward the 12 o'clock position. The needle was withdrawn from the 12 o'clock position, and the suture was pulled out. At this point, the 360° suture closure of the iris tissues was complete, and the two suture ends are in the same incision.

Following this, the intraocular sutures were knotted by tying the ends of the suture in a line knot extraocularly at the 12 o'clock position and pushing the knot into the eye with a lens positioning hook. The retinal forceps were used to enter the eye through the 8 o'clock incision, the end of the suture was pulled out of the eye, and the sutures at the 12 o'clock and 8 o'clock incisions were pulled in opposite directions to shrink the pupil to the planned diameter. Following this, three knots were made using the Siepser sliding knot technique[5], and intraocular scissors were used to trim the suture. The physician could adjust the size of the pupil as necessary (Figure 2).

RESULTS

Eight patients were included in the study (Table 1), of which 6 (75%) were male and 2 (25%) were female. The age range of the patients was 45-73y (mean, 63±9.3y). The atonic pupil was caused by ocular trauma in six cases and APAC in one case, and it appeared after cataract surgery in one case. The mean follow-up period was 10.5±3.6mo. The CDVA

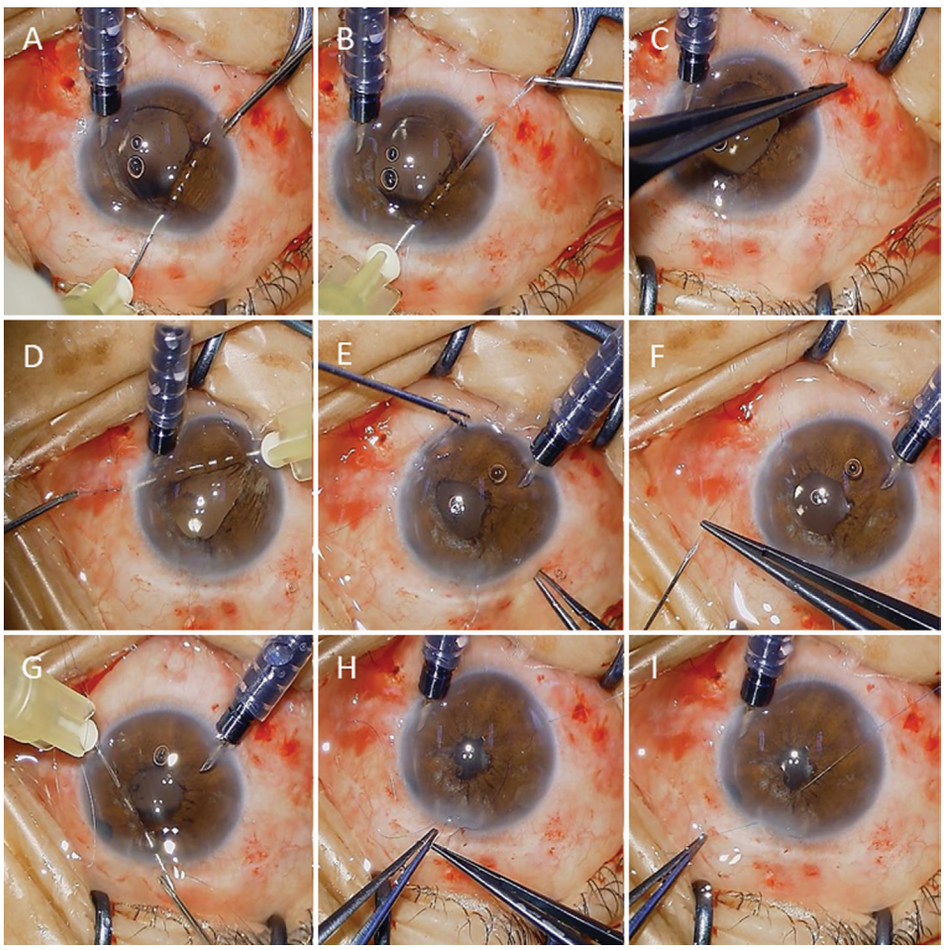

Figure 1 Intraoperative view of the surgical procedures.

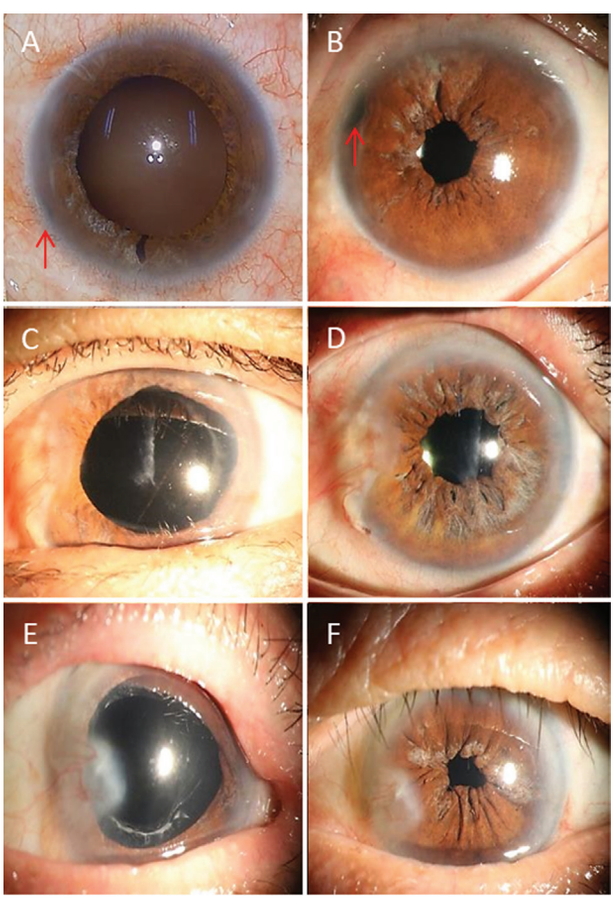

Figure 2 Clinical case presentation.

(logMAR) was 0.58±0.22 preoperatively and 0.20±0.10 at the last postoperative follow-up (P=0.002). The mean pupil size was 7.38±0.88 mm preoperatively and 3.09±0.71 mm postoperatively (P=0.000). The mean CECC was 2841±176/mm^2 preoperatively and 2692±143/mm^2 postoperatively (P=0.000). No intraoperative complications were reported. Throughout the follow-up period, all patients had essentially round or nearly round pupils, and there were no loose or broken sutures or sutures cutting the iris tissue. There were no complications such as hypotony, ocular hypertension, retinal detachment, or corneal endothelial cell loss on postoperative follow-up. The pupils were centered, and none of the patients had photophobia, glare, or diplopia.

DISCUSSION

Returning the pupil to its physiological state is the primary goal of iris reconstruction. Ophthalmologists can use several techniques available for pupil reduction and pupilloplasty in atonic pupil cases. The 30-G needle-guided 10-0 prolene purse-string suture pupilloplasty has many advantages.

The 30-G (0.3 mm×13 mm) needle has an appropriate hardness and does not bend easily during intraocular manipulation. Its length of 13 mm is greater than that of any two incisions used in the surgery. This technique does not require a needle holder; instead, the needle is attached to a syringe, which provides a

Table 1 Clinical data of the patients

Case	Sex	Age (y)	Complications associated with mydriasis	Combined operation	Preoperative			Postoperative		
					PD (mm)	CDVA (logMAR)	CECC (/mm^2)	PD (mm)	CDVA (logMAR)	CECC (/mm^2)
1	Male	45	Complete dislocation of the lens secondary to ocular trauma (3mo after PPV)	IOL implantation in ciliary sulcus	7	0.22	3127	3.2	0.15	2906
2	Male	63	Cataract secondary to ocular trauma	PHACO+IOL	7	0.70	2643	3.5	0	2534
3	Male	68	Traumatic complete dislocation of the lens	PPV; IOL implantation in ciliary sulcus	9	0.82	2703	3.4	0.22	2515
4	Male	73	Post-cataract surgery (aphakia for 2mo)	IOL implantation in ciliary sulcus	7	0.40	2686	1.5	0.22	2631
5	Male	70	Traumatic lens dislocation, vitreous hemorrhage (2mo after PPV)	IOL implantation in ciliary sulcus	8	0.40	2796	3.9	0.22	2678
6	Female	65	Traumatic lens dislocation, cyclodialysis cleft	PHACO+IOL; Ciliary body suturing	6.5	0.70	3066	3.2	0.30	2875
7	Female	68	APAC	PHACO+IOL	6.5	0.82	2863	3.0	0.30	2662
8	Male	54	Traumatic lens dislocation, vitreous hemorrhage	PPV; IOL implantation in ciliary sulcus	8	0.60	2847	3.0	0.15	2738

APAC: Acute primary angle closure; CDVA: Corrected distance visual acuity; CECC: Corneal endothelial cell count; logMAR: Logarithm of minimum angle of resolution; IOL: Intraocular lens; PD: Pupil diameter; PHACO: Phacoemulsification; PPV: Pars plana vitrectomy; SD: Standard deviation.

better grip, and the surgical difficulty does not worsen even if the needle is hand-held. The needle tip can be controlled more directly, the angle and direction of the needle can be changed more easily, and the distance between the suture points and between a suture point and the pupillary margin can be maintained using retinal forceps. Only penetration and withdrawal movements are required, and extraocular suture manipulation reduces the risk of damage to the iris tissue and adjacent tissues during suturing. The technique requires only three small incisions in the corneal margin, forming an isosceles triangle to complete the purse-string suturing of the pupil. The needle is passed between the two incisions, and the iris tissue is not pulled across the midline of the pupil, thus reducing the risk of hemorrhage. Closure with a long curved needle usually requires more than three corneal margin incisions. The long curved needle must pass through the anterior chamber several times, and withdrawal from the cornea may take a long time to avoid entrapment of the corneal tissue. This also requires the ophthalmologist to use a needle holder to guide the needle and maintain its stability. The technique of iris reconstruction with needle-guided sutures reported by Safran *et al*[26] uses intraocular forceps in the anterior chamber to hold the suture. The bevel of the needle must be fully exposed to facilitate holding the suture, which can be difficult with intraocular forceps due to the softness and fragility of the iris tissue. Furthermore, excessive anterior chamber manipulation may increase the risk of hemorrhage and peripheral tissue damage.

The pupillary purse-string suturing is more effective than the standard multiple interrupted iris-suturing technique. The pupil is rounder, more uniform, and more centered with lesser tension on the peripheral iris with the pupillary purse-string suturing technique than with the standard technique. The pupil is kept centered in a near-physiological state, which is more beneficial for visual acuity. The size of the pupil can be adjusted intraoperatively using the suture, and the visual acuity has been improved by some researchers by reducing higher-order aberrations using "pinpoint" pupilloplasty[27-30]. Figure 2C, 2D showed ocular trauma resulting in a central corneal scar with a pupil fixed at 3.9 mm. Figure 2E, 2F showed -4.5 diopters of astigmatism with a pupil fixed at 1.5 mm and postoperative uncorrected distance visual acuity of 0.35 and CDVA of 0.22. The pupillary purse-string suture requires only one intraocular knot, thus requiring less time. When removing the sutures to enlarge the pupil, the purse-string pupilloplasty technique has the advantage of cutting the suture at only one point and removing it, whereas multiple interrupted sutures are usually covered with iris tissue and must be cut at several points.

A technical point of note is how to withdraw the needle tip smoothly from the eye via the lateral incision. There are three ways to do so. First, retinal forceps can be used to hold the needle tip and withdraw it. Second, a blunt rounded needle can be used to guide withdraw the needle tip. Third, the needle can be directly withdrawn puncture out from the corneal margin, after which the suture is pulled out from the 30-G needle, and the retinal forceps are introduced into the anterior chamber through the corresponding surgical incision to pull out the suture. In addition, if the iris tissue is significantly atrophic, it should be sutured as close to the normal position as possible to maintain moderate suture tension to prevent tissue tearing.

In conclusion, the 30-G needle-guided 10-0 prolene purse-string suture pupilloplasty allows extraocular suture manipulation while enabling precise adjustment of the size of the atonic pupil, allowing the pupil to remain naturally round for a long time postoperatively. This study demonstrates that this approach is safe and produces satisfactory results.

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