• Letter to the Editor •

A modified micro-injector for subretinal injection and aspiration in vitreoretinal surgery

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Dear Editor,

Subretinal surgical techniques, which involve accessing the subretinal space, located between the retina and the retinal pigment epithelium (RPE)[1], have received increasing attention in the management of subretinal diseases. The limited availability of the MicroDose Injection has prompted the development of alternative systems. Therein, we designed a modified micro-injector controlled by a vitrectomy system, enabling both subretinal injection and aspiration in vitreoretinal surgeries.

Ethical Approval The study followed the principles outlined in the Declaration of Helsinki and was approved by the ethics committee of the First Affiliated Hospital of Soochow University (No.2025669). Written informed consent was obtained from all participants prior to the study, and no financial compensation was provided.

Patients diagnosed with sub-macular hemorrhage (SMH), presenting with hemorrhages larger than 2 discs areas that extended to the vascular arcades within 14d of onset were included. In addition, patients with subretinal perfluorocarbon liquid (PFCL) following pars plana vitrectomy (PPV) were also included. Exclusion criteria included patients with diabetes, uncontrolled hypertension and severe cardiovascular disease, a history of malignancy, or mental diseases.

The micro-injector consisted of a 1 mL syringe, a viscous fluid control (VFC) tube, a connecting adaptor and a sterile latex strip. First, the plunger and stopper were removed from 1 mL syringe, and the stopper was reinserted from the back of 1 mL syringe. The 10 mL syringe adaptor at the bottom of the VFC tube was cut off, and the cut end of the VFC tube was connected to the bottom of the 1 mL syringe using the connecting adaptor. A sterile latex strip was wrapped around the connecting adaptor of the 1 mL syringe side to ensure a secure seal. A micro-needle was then fixed to the tip of 1 mL syringe (Figure 1). During surgery, aspiration or injection was performed using VFC tube under controlled pressure *via* the vitrectomy system (Alcon Constellation Vision System; Alcon).

Before surgery, two micro needles—38 G (Mingren, China) and 41 G (DORC, Netherlands)—were tested according to literature to confirm the appropriate injection pressure. At a pressure of 6 psi (41 kPa)[2], two needles exhibited extremely low speeds of approximately 0.023 mL/s and 0.008 mL/s, respectively. At higher pressure of 25–35 psi (173-242 kPa)[3], both produced a stream-like flow. With the recommended range 12 to 16 psi (83 to 110 kPa)[4], the 41 G needle delivered fluid drop by drop at pressures below 15 psi (104 kPa), with minimal interruption, and transitioned to a stream at higher pressures. In contrast, the 38 G needle consistently produced a stream-like flow. Based on these, a pressure of 15 psi (104 kPa) with the 41 G needle was chosen for subretinal injection procedures.

All surgeries were performed by one experienced surgeon. For the SMH, the procedure began with a standard PPV. Indocyanine green dye (ICG) was used to stain and assist in peeling the internal limiting membrane (ILM), preserving the macular pit. The on-spot prepared injector device was then connected to vitrectomy machine and tissue plasminogen activator (t-PA) was injected into the subretinal space under 15 psi (104 kPa) pressure. A total of 0.2 mL of t-PA (0.25 mg/mL) was injected by 41 G micro-needle at the temporal region, approximately 2 disc diameters from the macular pit. Following this, fluid-air exchange was performed. For the subretinal PFCL after PPV and silicone oil tamponade, silicone oil removal and ILM peeling were performed first, then the same injector device was utilized with the needle carefully advanced into the subretinal space to reach the PFCL bubble.

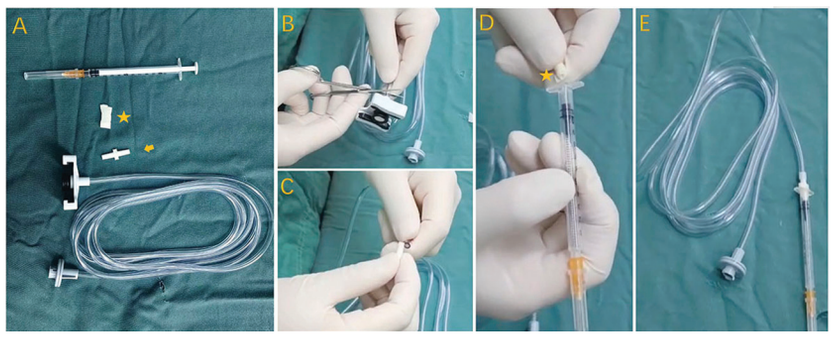

Figure 1 On-spot preparation of a modified micro-injector A: The micro-injector consists of a 1 mL syringe, a viscous fluid control (VFC) tube, a connecting adaptor (arrow) and a sterile latex strip (star); B: Cut at the end of the VFC tube; C: Use the connecting adaptor to link the cut end of the VFC tube; D: A sterile latex strip (star) is wrapped around the connecting adaptor, and connected to bottom of 1 mL syringe; E: Connect to the viscous fluid injection system.

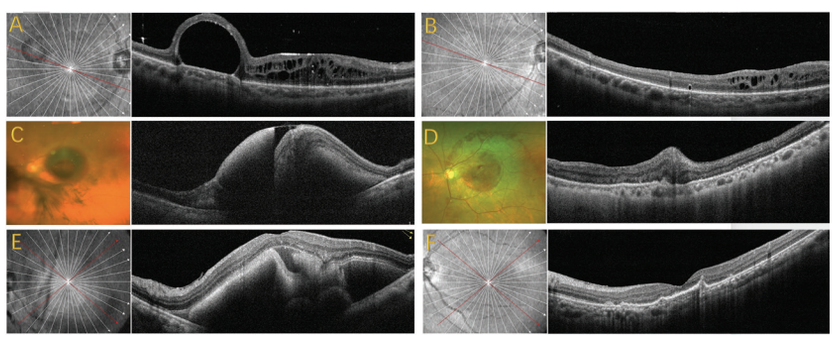

Figure 2 Pre- and post-operation examinations of three cases treated using the modified micro-injector Case 1 was a 50-year-old male with retinal detachment previously treated with PPV and SO tamponade. Postoperative OCT (A) revealed a subretinal PFCL bubble. During SO removal three months later, the PFCL was successfully aspirated using the modified injector. Follow-up OCT image one month after the procedure (B) confirmed complete PFCL removal without notable disruption of the ellipsoid zone. Case 2 and Case 3 were two elderly female patients with SMH, confirmed by fundus photography and OCT (C, E). One month after PPV and subretinal t-PA injection using the modified injector, both OCT and fundus examination (D, F) demonstrated liquefaction and resolution of the hemorrhage. PPV: Pars plana vitrectomy; SO: Silicone oil; OCT: Optical coherence tomography; PFCL: Perfluorocarbon liquid; SMH: Sub-macular hemorrhage; t-PA: Tissue plasminogen activator.

Table 1 Demographic characteristics and preoperative and postoperative data of six eyes with subretinal PFCL or SMH

Patient	Gender	Age	Eye	Pre-OCT	Vitreous	Duration	History treatments	Pre-BCVA	Surgery	Post-BCVA
1	Male	50	R	Subretinal PFCL	SO	3mo	PPV and SO tamponade for RD	FC/40 cm	PPV with SO extraction and PFCL suction and gas tamponade	FC/50 cm
2	Male	68	L	Subretinal PFCL	SO	4mo	PPV and SO tamponade for RD	FC/20 cm	PPV with PFCL suction and gas tamponade	FC/50 cm
3	Female	78	L	SMH	Vitreous	2wk	Anti-VEGF for 3 times	HM/BE	PPV with t-PA injection and gas tamponade	FC/20 cm
4	Male	55	L	SMH	Vitreous	10d	None	HM/BE	PPV with t-PA injection and gas tamponade	0.04
5	Female	63	R	SMH	Vitreous	12d	None	FC/30 cm	PPV with t-PA injection and gas tamponade	0.04
6	Female	71	R	SMH	Vitreous	1wk	None	FC/BE	PPV with t-PA injection and gas tamponade	0.15

PFCL: Perfluorocarbon liquid; SMH: Sub-macular hemorrhage; Pre-OCT: Preoperative optical coherence tomography; SO: Silicone oil; RD: Retinal detachment; Pre-BCVA: Preoperative best-corrected visual acuity; Post-BCVA: Postoperative best-corrected visual acuity; VEGF: Vascular endothelial growth factor; PPV: Pars plana vitrectomy; t-PA: Tissue plasminogen activator; HM/BE: Hand motion/before eye; FC: Finger count; R: Right eye; L: Left eye.

Aspiration pressure was carefully controlled *via* foot pedal, starting at a low rate (set at 650 mm Hg[5]), and once the retina flattened, the needle was carefully withdrawn and laser retinopexy was not performed.

Six patients were enrolled (Table 1). All cases showed promising anatomical and visual outcomes without severe postoperative complications. Fundus photography and optical coherence tomography (OCT) analysis on patients both pre- and postoperatively provided detailed insights into the improvements in retinal structure (Figure 2), and best-corrected visual acuity (BCVA) showed improvement in all cases.

DISCUSSION

SMH is characterized by blood accumulation beneath the neurosensory retina[6] and sub-retinal PFCL is one of the known complications of PFCL-assisted vitrectomy[7]. To reduce the potential risk of macular damage associated with the conditions[6-7], subretinal t-PA injection combined with PPV could facilitate the liquefaction and faster removal of

blood clots[8]. Using a small-gauge needle connected to the vitrectomy system to aspirate the subretinal PFCL has proven helpful in most cases[5]. Consequently, several modified methods have been developed due to the lack of standardized commercial one.

Reported devices were designed to connect the 1 mL syringe to the microneedle while adapting the 10 mL syringe for compatibility with VFC unit, and then to employ various approaches to combine the two syringes. It involved the method that cutting off the tip of a 10 mL syringe of viscous fluid pack and fitting a 1 mL syringe inside it[2,9], or using an extension tube connecting[3]. Another novel technique was to shorten 1 mL insulin syringe and plunger, then put through a perforated piston, inserting it inside a 10 mL syringe of viscous fluid pack[10]. Our modified one simplified this by directly connecting a 1 mL syringe to the VFC system *via* a connecting adaptor. It eliminated the need for the cutting process and avoided the operational inconvenience caused by the increased length when combining two syringes. Surgeons can operate independently and comfortably and set a maximum pressure limit using the Alcon Constellation Vision System by foot control. The main limitation lay in the manual connection process, as its success relied heavily on the secure sealing of the connecting adaptor. Therefore, preoperative testing was conducted, and the connection was closely monitored throughout the procedure.

All common risks associated with vitreoretinal surgery—including retinal detachment and cataract formation—should be taken into account[11], along with other serious complications, such as macular hole formation, RPE damage, and retinotomy enlargement[3,8]. To minimize the incidence, small-gauge cannulas with carefully controlled low aspiration rates were employed, and the procedure was performed with ILM peeling and preservation the macular pit. Meanwhile, excessively low pressure may prolong the procedure duration, potentially increasing the risk of retinotomy enlargement, while relatively higher pressure could raise the risk of retinal injury. Therefore, performing a pressure test prior to surgery is also essential. The precautions may explain the low rate of severe complications observed in our cases.

One of the limitations was the small sample size, which may contribute to the low observed complication rate. Therefore, further investigations with larger cohorts are necessary to validate these findings and to fully assess the safety and efficacy of the device. Another limitation was the failure of the modified injector to function effectively during drainage of macular cysts. It was suggested that contents of chronic cysts may lead to obstruction[12]. To investigate, mixtures of ophthalmic viscoelastic device (OVD) and deionized water at varying ratios were tested. Under constant temperature, increasing the OVD proportion eventually halted flow, suggesting the suction effectiveness was influenced by physical properties of the fluid. Further comprehensive studies are warranted to optimize the device for broader applications and therapeutic efficacy.

In conclusion, the modified micro-injector may represent a practical and effective option. It could provide convenient control, facilitating subretinal injection and aspiration procedures, and serve as a valuable tool in vitreoretinal surgeries.

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