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COMPARING VITRECTOMY, SILICONE OIL ENDOTAMPONADE WITH/WITHOUT CYCLOPEXY TO TREAT CYCLODIALYSIS CLEFTS WITH SEVERE OCULAR TRAUMA

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Purpose: Comparing the anatomical and functional outcomes of vitrectomy, silicone oil endotamponade without cyclopexy (VEWOC) and with cyclopexy (VEWC) in patients with traumatic cyclodialysis clefts and severe ocular comorbidities.

Methods: A total of 55 patients (55 eyes) with traumatic cyclodialysis clefts were divided into VEWOC and VEWC groups according to the surgery undergone. Besides the cyclodialysis clefts, all study eyes had one or more additional conditions caused by severe ocular trauma: cataract, lens dislocation, vitreous hemorrhage, retinal detachment, choroidal detachment, maculopathy, suprachoroidal hemorrhage, subretinal hemorrhage, or proliferative vitreoretinopathy. The minimum postoperative follow-up period for all patients was six months. The main measures of outcome were rate of successful anatomical repair, intraocular pressure, and best-corrected visual acuity.

Results: Both the VEWOC group (33 eyes) and the VEWC group (22 eyes) showed significant improvement in postoperative best-corrected visual acuity and intraocular pressure at the final follow-up. The groups had no significant differences in terms of anatomical success rates (VEWOC 29/33 vs. VEWC 20/22, $P = 1.000$), final best-corrected visual acuity (VEWOC 1.60 ± 0.76 [median Snellen acuity: counting fingers, range: light perception to 20/20] vs. VEWC 1.46 ± 0.66 [median Snellen acuity: 20/800, range: light perception to 20/32], $P = 0.485$), and final intraocular pressure (VEWOC 13.40 [8.20–17.80] vs. VEWC 11.40 [6.65–14.00] mmHg, $P = 0.311$). However, the intraocular pressure on postoperative Day 1 was significantly different between the groups (VEWOC 10.40 [6.40–14.60] vs. VEWC 6.40 [4.70–7.98] mmHg, $P = 0.002$).

Conclusion: This study showed that both surgical approaches were equally effective in treating cyclodialysis clefts secondary to severe ocular trauma. Therefore, it may be unnecessary to perform cyclopexy in addition to the vitrectomy procedure in such cases.

RETINA 41:1174–1181, 2021

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None of the authors has any financial/conflicting interests to disclose.

A. Wang—methodology, data curation, software, and writing-original draft preparation. Z. Zhao—conceptualization, methodology, writing- reviewing and editing, and validation.

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A cyclodialysis cleft is a condition wherein the longitudinal ciliary muscle is detached from the scleral spur.[1] This forms an abnormal communication between the anterior chamber and the suprachoroidal space, which leads to chronic ocular hypotony, corneal edema, shallowing of the anterior chamber, cataract, choroidal effusion, optic nerve edema, retinal and choroidal folds, hypotonous maculopathy, retinal pigment epithelium atrophy, and loss of vision.[2]

Cyclodialysis clefts often occur due to trauma or as complications after ophthalmic procedures.[3] Although gonioscopy is the gold standard test for the diagnosis of a cyclodialysis cleft, ultrasound biomicroscopy (UBM) is more widely used in cases with ocular trauma, which is not affected by medial opacity. The treatment options for cyclodialysis clefts include topical cycloplegic agents, injection of viscoelastic material or blood plasma, transscleral diathermy, laser photocoagulation, cyclocryotherapy, cyclopexy, scleral-sutured capsular tension ring, intraocular lens, scleral buckling, vitrectomy, and endotamponade.[2–4] The ophthalmologist may choose one or more of these procedures to close the cyclodialysis cleft depending on its size and the presence of other ocular comorbidities, such as lens dislocation, vitreous hemorrhage, and retinal detachment.

For traumatic cyclodialysis clefts associated with severe vitreous or chorioretinal pathology, vitrectomy with silicone oil endotamponade is the preferred procedure for treatment. However, it is unclear whether cyclopexy should be combined with the vitrectomy procedures or not. Therefore, this study retrospectively compared the anatomical and functional outcomes of these two operations.

Methods

This is a retrospective, comparative clinical study. The medical records of patients with cyclodialysis clefts secondary to severe ocular trauma were reviewed. All patients were treated at the Eye Hospital of Wenzhou Medical University between January 2013 and October 2019. Cases with missing records, history of glaucoma, or silicone oil–sustained eyes were excluded. The study was approved by the Ethics Committee of the Eye Hospital of Wenzhou Medical University and was conducted in accordance with the tenets of the Declaration of Helsinki.

The inclusion criterion was severe ocular trauma[5] resulting in a cyclodialysis cleft in addition to other anterior and posterior segment damage (including cataract, lens dislocation, vitreous hemorrhage, retinal detachment, choroidal detachment, maculopathy, suprachoroidal hemorrhage, subretinal hemorrhage, or proliferative vitreoretinopathy). The 55 patients (55 eyes) who were recruited for this study were divided into two groups according to the surgical treatment received: vitrectomy, silicone oil endotamponade without cyclopexy (VEWOC) group and vitrectomy, silicone oil endotamponade with cyclopexy (VEWC) group. All patients were examined and treated by the same surgeon (Z.Q.Z.).

All patients underwent a preoperative ophthalmic examination including best-corrected visual acuity (BCVA), intraocular pressure (IOP) measurement, slit-lamp photography, B-scan ultrasound, and UBM. Best-corrected visual acuity was measured using the standard logarithmic vision chart, and the value was transferred to the digital logarithm of the minimum angle of resolution scale for statistical analysis.[6,7] IOP was measured thrice using a pneumotonometer TX-20 (Canon, Inc, Tokyo, Japan) and the average value was calculated and documented. B-scan ultrasound was performed to assess the condition of the vitreous cavity and the retina. UBM HF 35-50 (OTI, Toronto, Canada) was used to identify the size of the cyclodialysis cleft. All patients were administered topical steroids and antibiotics after injury; additional general antibiotics were prescribed in cases with open globe injuries. Topical atropine 1% was used to make the diagnosis of cyclodialysis.

Patients underwent the surgeries under either retrobulbar or general anesthesia. A 3-port 23-gauge transconjunctival pars plana vitrectomy was performed to resect the vitreous and intraocular opacification. In addition, a pars plana–based lensectomy, phacofragmentation, or phacoemulsification was performed for cataract and lens dislocation. Thereafter, some of the patients underwent a modified procedure of cyclopexy. After the careful confirmation of the cyclodialysis cleft with a corneal contact lens or a wide-angle viewing system intraoperatively, the surgeon marked the site on the cleft where sutures were to be placed. A limbus conjunctival flap was created, which extended 1 clock hour from the margins of the marked cleft. One long straight needle with a 10-0 polypropylene string was used to pierce the sclera (1.5 mm posterior to the limbus) and detach ciliary body at the location of the cyclodialysis cleft. A 25-gauge needle (external diameter 0.5 mm, inner diameter 0.25 mm, length 16 mm) was used as a bridge to help the needle through the pars plana infusion cannula or limbus incision opposite to the cleft. Subsequently, the needle was returned into the eye to pierce the other part of the detached ciliary body and the spur to surface of sclera (the needle distance was usually 3 mm) with the assistance of the 25-gauge needle again. The 10-0 polypropylene string was then tied. The procedures of the internal cyclopexy technique are presented in Figure 1. The abovementioned steps were repeated until all the cleft was sutured. The knots of the sutures were placed on the surface of the sclera and were covered by the conjunctiva. Finally, endolaser photocoagulation or cryotherapy was performed for retinal breaks and degeneration. Fluid–air exchange and silicone oil endotamponade were accomplished.

All patients were asked to maintain a fixed head position to maintain the detached retina or ciliary body superiorly for at least 2 weeks postoperatively. If the location of detached retina conflicted with the detached ciliary body, the detached retina was given priority. Topical corticosteroids and antibiotics were

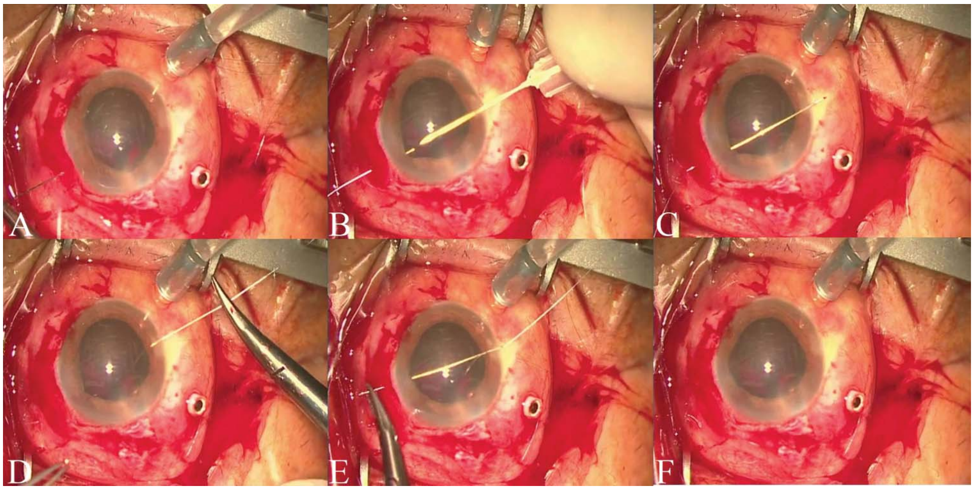

Fig. 1. Images of the internal cyclopexy technique: (**A**) A long straight needle with 10-0 polypropylene string is used to pierce the sclera and detach the ciliary body at the site of the cyclodialysis cleft. **B** and **C.** A second 25-gauge needle is used as a bridge to help the needle through the corneal limbus incision opposite to the cleft. **D** and **E.** The needle is returned into the eye, to pierce the other part of the detached ciliary body and the spur to the surface of the sclera with the assistance of the 25-gauge needle. **F.** The 10-0 polypropylene string is then tied on the surface of the sclera.

prescribed. Usually, the silicone oil was removed and the artificial lens was implanted after 3 to 6 months. Postoperative examinations were planned at days 1, 3, and 10; months 1, 3, 6, and 12; and yearly thereafter. UBM examinations were usually repeated on postoperative Day 10. Postoperative clinical data including BCVA, IOP, complications such as IOP spikes[8] (IOP ≥ 25 mmHg), hypotony[3] (IOP ≤ 5 mmHg), and secondary glaucoma were collected. Intraocular pressure spikes were treated with antihypertensive therapy. Topical corticosteroids were used for hypotony at earlier stages. Antiglaucoma surgery was performed for cases with secondary glaucoma.

Statistical analysis was performed using SPSS software v19.0 (IBM, Armonk, NY). Continuous variables were expressed as mean ± SD or median (25th percentile–75th percentile) [M (P25–P75)] wherever appropriate. The chi-square test, *t*-test, and nonparametric test were used to compare clinical results. P values < 0.05 were considered statistically significant.

Results

The research included 55 eyes (34 right eyes) of 55 patients (53 men) with a mean age of 48.96 ± 11.35 years (range: 22–71 years). These patients were formed by 26 cases of closed globe injury (contusion: 25/26, 96.2% and lamellar laceration: 1/26, 3.8%) and 29 cases of open globe injury (rupture: 20/29, 69.0%; penetrating: 7/29, 24.1%; perforating: 1/29, 3.4%; and intraocular foreign body: 1/29, 3.4%). All eyes had additional severe trauma complications, such as hyphema (44/55, 80.0%), cataract (41/55, 74.5%), lens dislocation (40/55, 72.7%),

Table 1. Preoperative Clinical Data for 55 Patients With Cyclodialysis Clefts

	VEWOC Group	VEWC Group	*P*
Number of eyes	33	22	
Age (in years)	48.70 ± 12.38	49.36 ± 9.86	0.833
Gender (female/male)	1/32	1/22	1.000
Injury type (closed/open)	13/20	13/9	0.152
Injury time (in days)	9.00 [7.00–14.00]	8.50 [5.75–11.00]	0.258
Cyclodialysis extent (clock hours)	3.00 [2.00–4.00]	4.00 [2.00–6.25]	0.096
Preoperative BCVA (logMAR)	2.00 [2.00–2.50] (median Snellen acuity: HM, range: NLP to 20/400)	2.50 [2.00–2.50] (median Snellen acuity: LP, range: NLP to CF)	0.701
Preoperative IOP (in mmHg)	6.30 [5.50–8.80]	5.95 [4.28–7.00]	0.183
Cataract	24/33 (72.7%)	17/22 (77.3%)	0.705
Lens dislocation	25/33 (75.8%)	15/22 (68.2%)	0.537
Maculopathy	25/33 (75.8%)	16/22 (72.7%)	0.800
Suprachoroid hemorrhage	9/33 (27.3%)	6/22 (27.3%)	1.000
Subretinal hemorrhage	20/33 (60.6%)	15/22 (68.2%)	0.567
PVR	13/33 (39.4%)	5/22 (22.7%)	0.197

Continuous variables are expressed as mean ± SD (x ± s) or median [25th percentile–75th percentile] (M [P25–P75]).

CF, counting fingers; HM, hand motion; logMAR, logarithm of the minimum angle of resolution; NLP, no light perception; PVR, proliferative vitreoretinopathy.

Table 2. Comparison of Preoperative and Postoperative Values of Both Groups

	Preoperative	Postoperative	*P*
VEWOC group			
BCVA (logMAR)	2.00 [2.00–2.50] (median Snellen acuity: HM, range: NLP to 20/400)	1.70 [1.15–2.00] (median Snellen acuity: CF, range: LP to 20/20)	<0.001
IOP (mmHg)	6.30 [5.00–8.80]	13.40 [8.20–17.80]	<0.001
VEWC group			
BCVA (logMAR)	2.50 [2.00–2.50] (median Snellen acuity: LP, range: NLP to CF)	1.61 [1.00–2.00] (median Snellen acuity: 20/800, range: LP to 20/32)	<0.001
IOP (mmHg)	5.95 [4.28–7.00]	11.40 [6.65–14.00]	0.001

Continuous variables were expressed as median [25th percentile–75th percentile] (M [P25–P75]).
CF, counting fingers; HM, hand motion; logMAR, logarithm of the minimum angle of resolution; NLP, no light perception.

vitreous hemorrhage (54/55, 98.2%), retinal detachment (50/55, 90.9%), choroidal detachment (49/55, 89.1%), maculopathy (41/55, 74.5%), suprachoroidal hemorrhage (15/55, 27.3%), subretinal hemorrhage (35/55, 63.6%), or proliferative vitreoretinopathy (18/55, 32.7%) (Details of all the patients are presented in Table 1).

The median extent of the cyclodialysis cleft was 3.00 clock hours (P25–P75: 2.00–5.00 clock hours). In eight eyes, the extent of the cyclodialysis cleft was larger than six clock hours. The median preoperative BCVA (logarithm of the minimum angle of resolution) was 2.00 (P25–P75: 2.00–2.50) (median Snellen acuity: hand motion, range: no light perception [LP] to 20/400) including seven eyes with no LP. The median preoperative IOP was 6.3 mmHg (P25–P75: 5.00–8.80 mmHg), which included six cases with more than 10 mmHg (median [M]: 17.3 mmHg; range: 10.5 to 25.1 mmHg). The data encompassing 33 eyes in the VEWOC group and 22 in the VEWC group are shown in Table 1. The width of the cyclodialysis cleft in the VEWOC group (M [P25–P75]: 3.00 [2.00–4.00] clock hours) was smaller than that of the VEWC group (M [P25–P75]: 4.00 [2.00–6.25] clock hours). However, all the preoperative outcomes showed no statistically significant differences between the two groups (Table 1).

Intraoperatively, lenses were removed for all cases of cataract or lens dislocation and one eye underwent vitrectomy twice to reattach the retina.

After VEWOC and VEWC treatments, all the patients were followed up for at least six months. The final postoperative BCVA and IOP values of both groups had significantly improved compared with the preoperative values, with all *P* values ≤0.001 (a comparison of the preoperative and postoperative BCVA and IOP values is presented in Table 2). The postoperative anatomical success rates were 29 of the 33 (87.9%) and 20 of the 22 (90.9%), respectively. Figure 2 shows a representative case in the VEWOC group. There were no significant differences between the two groups in terms of this parameter (VEWOC 29/33 vs. VEWC 20/22, *P* = 1.00). Three unsuccessful eyes underwent a repeat cyclopexy procedure for complete cleft repair, whereas other patients refused surgical repair for normal IOP. The final BCVA was not significantly different between the two treatment groups (VEWOC 1.60 ± 0.76 [median Snellen acuity: counting fingers, range: LP to 20/20] vs. VEWC 1.46 ± 0.66 [median Snellen acuity: 20/800, range: LP to 20/32], *P* = 0.485). During the follow-up period, the IOP of postoperative Day 1 was significantly different between the two groups (VEWOC 10.40 [6.40–14.60] vs. VEWC 6.40 [4.70–7.98] mmHg, *P* = 0.002). However, the IOP values showed no significant differences at other follow-up times. The postoperative findings of all the patients are tabulated in Table 3. The mean values of IOP during the follow-up period are presented as a graph in Figure 3.

Postoperative complications included temporary IOP spike, secondary glaucoma, and hypotony. In the VEWOC group, the incidence rate of IOP spike was higher than that of the VEWC group (VEWOC 17/33 vs. VEWC 8/22, *P* = 0.269). At the final follow-up visit, each groups still presented a case of ocular hypertension respectively, and the case of VEWC group was diagnosed with glaucoma. There were nine eyes with hypotony postoperative, and the incidence rate of hypotony was higher in the VEWC group than that of the VEWOC group (VEWOC 5/33 vs. VEWC 4/22, *P* = 1.000). However, these values were not significantly different between the two groups (Table 3).

Discussion

This study compared VEWOC and VEWC as treatment options for cases with traumatic cyclodialysis clefts.

For large cyclodialysis clefts or those cases with concomitant retinal pathology, vitrectomy is used.[3] However, there are only a few reports on cyclodialysis in the literature owing to the rarity of this condition.

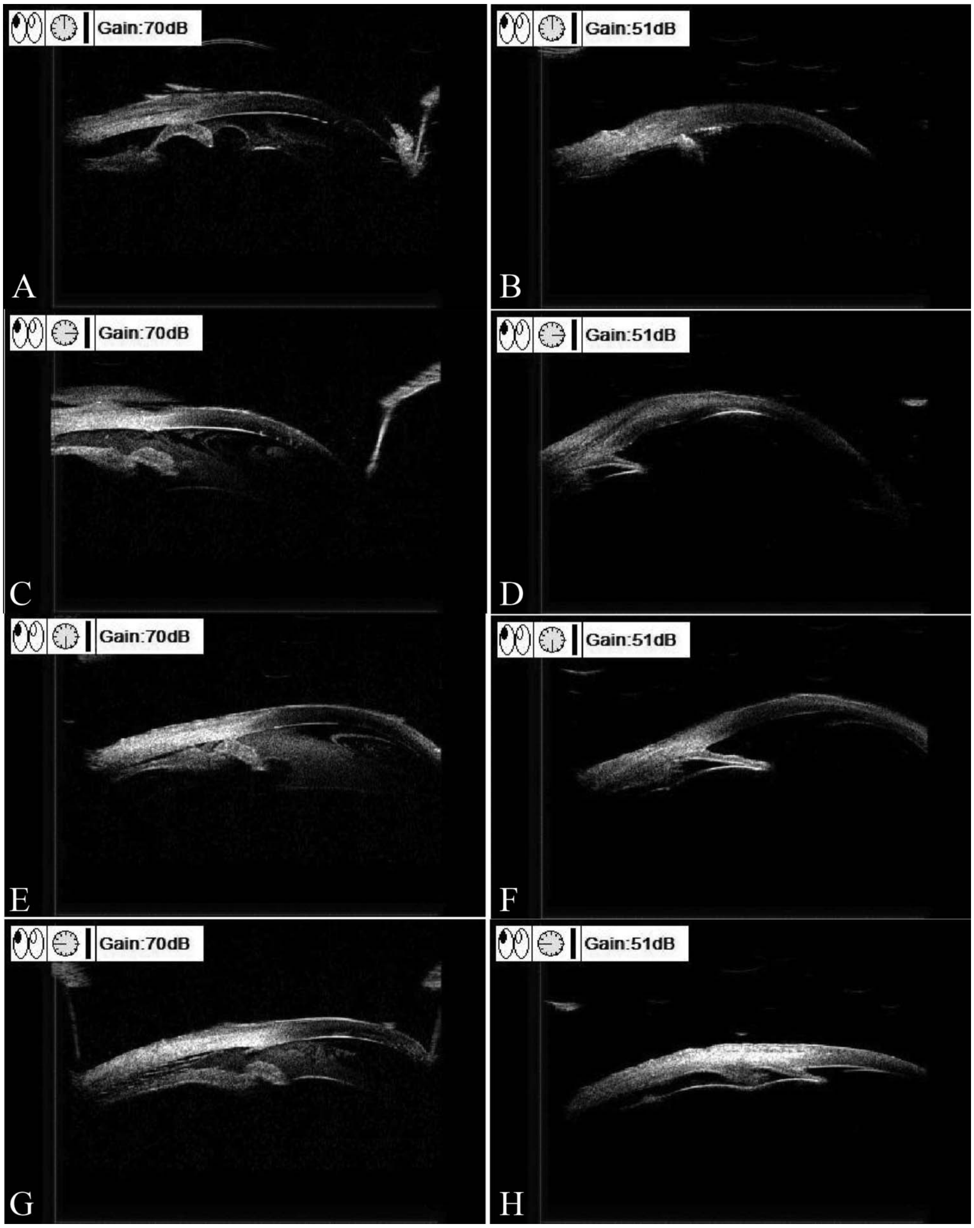

Fig. 2. Preoperative and postoperative UBM images in the VEWOC group. **A**, **C**, **E**, and **G.** UBM showing cyclodialysis clefts extending from the 9-o'clock to the 3-o'clock position; the iris (at 12-o'clock position) is adhered to the chamber angle with the assistance of topical atropine 1%. The other ciliary body is also detached. **B**, **D**, **F**, and **H.** UBM images taken 3 months after the VEWOC surgery showing that the cyclodialysis clefts are all closed.

Hoerauf et al, Helbig et al, and Takaya et al reported 1, 3, and 4 patients with cyclodialysis successfully treated with vitrectomy, cryotherapy, and gas endotamponade, respectively.[9–11] Meanwhile, Ishida et al reported a case treated by vitrectomy, cyclopexy with transscleral diathermy, and gas tamponade.[12] Medeiros et al[13] introduced the surgical method of vitrectomy, silicone oil, or gas endotamponade. A recent research studied large cyclodialysis clefts treated by multiple surgical steps, including vitrectomy, cryotherapy, phacoemulsification with placement of a capsular tension ring, and gas tamponade.[14] However, all these studies had a small sample size and were noncomparative in nature. The study conducted by Xu et al[15] compared the results of cyclopexy versus treatment procedures with vitrectomy, endophotocoagulation, and gas/silicone oil endotamponade. Popovic et al[16] recently reported a large sample, multicenter retrospective study, describing outcomes of 36 cases after the treatment for cyclodialysis clefts. Several surgical procedures including cryotherapy, endophotocoagulation, implantation of capsular tension ring, cyclopexy, and gas/silicone oil endotamponade may be jointly performed to close the cleft.[2] As no clear consensus has been reached regarding the treatment method, there are no uniform guidelines for the treatment of cyclodialysis clefts with vitrectomy. Therefore, this study was conducted to analyze whether cyclopexy should be performed in combination with vitrectomy and silicone oil

Table 3. Postoperative Findings in Patients With Cyclodialysis Clefts

	VEWOC Group	VEWC Group	*P*
Anatomical success rate	29/33 (87.9%)	20/22 (90.9%)	1.000
Postoperative BCVA (logMAR)	1.60 ± 0.76 (median Snellen acuity: CF, range: LP to 20/20)	1.46 ± 0.66 (median Snellen acuity: 20/800, range: LP to 20/32)	0.485
Postoperative IOP (mmHg)			
1 day	10.40 [6.40–14.60]	6.40 [4.70–7.98]	0.002
3 days	8.10 [6.60–15.70]	8.30 [6.88–18.53]	0.938
10 days	12.10 [6.70–20.75]	7.50 [6.70–15.63]	0.257
1 month	11.30 [8.00–21.50]	9.00 [6.68–19.08]	0.167
3 months	15.56 ± 9.31	11.35 ± 5.09	0.059
6 months	13.20 [8.90–17.35]	11.70 [9.36–14.00]	0.439
Final visit	13.40 [8.20–17.80]	11.40 [6.65–14.00]	0.311
IOP spike	17/33 (51.5%)	8/22 (36.4%)	0.269
Hypotony	5/33 (15.2%)	4/22 (18.2%)	1.000

Continuous variables are expressed as mean ± SD (x ± s) or median [25th percentile–75th percentile] (M [P25–P75]).
CF, counting fingers; logMAR, logarithm of the minimum angle of resolution.

endotamponade to enhance the success rate in cases with concomitant traumatic comorbidities.

Although this consecutive case series study was not randomized, there were no significant differences between the two treatment groups in terms of preoperative data. However, the VEWC group had a larger trend in the extent of the cyclodialysis cleft than the VEWOC group (VEWOC 3.00 [2.00–4.00] vs. VEWC 4.00 [2.00–6.25] clock-hours). The surgeon's choice of VEWC for treatment of larger cyclodialysis clefts may be due to the consideration of the large width of the cyclodialysis cleft; if left swinging in the vitreous cavity, it might negatively influence the operation and may lead to iatrogenic retinal and choroidal injury. Furthermore, the surgeon might have unconsciously selected more procedures to ensure the closure of the larger cyclodialysis clefts.

The postoperative values of BCVA, IOP, and anatomical success rates of both groups were ultimately favorable; however, the data showed no significant differences between the two groups. These results imply that vitrectomy and silicone oil endotamponade repairing in itself was sufficient and that additional surgical procedures were not necessary. The principle of this surgical method is to apply silicone oil endotamponade to reattach the cyclodialysis; the silicone oil is space occupying, maintains ocular anatomical features, prevents choroidal effusion, isolates the ciliary body from inflammatory mediators that can adversely affect aqueous production,[17–19]

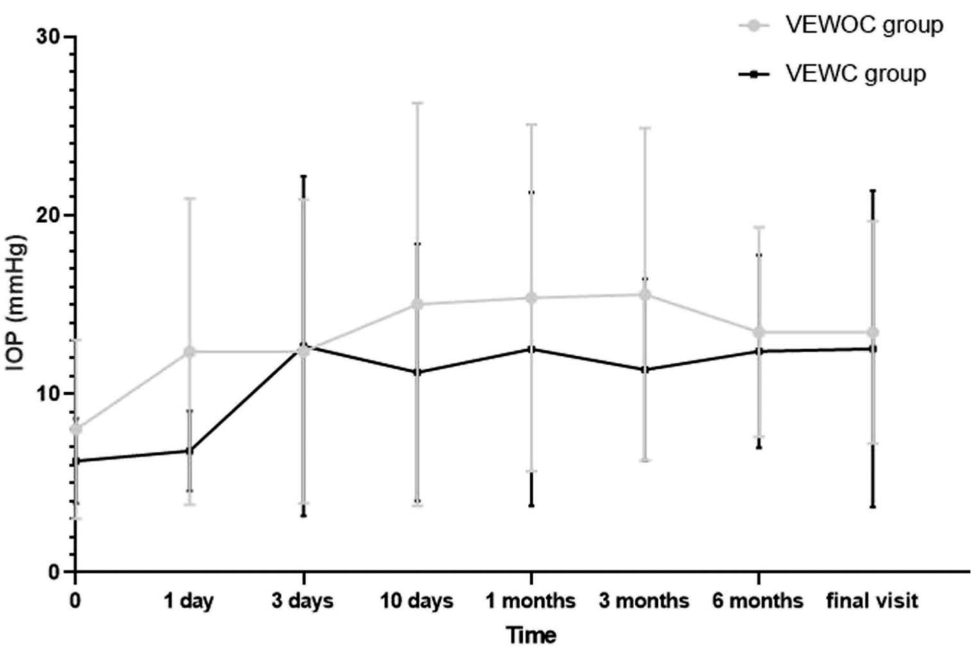

Fig. 3. Postoperative IOP profile after VEWOC and VEWC.

approximates the detached ciliary body to the scleral spur, and aids its subsequent reattachment.[9,13]

During the follow-up period, both groups revealed a diverse IOP profile. For the VEWOC group, the IOP was significantly raised on postoperative Day 1 itself. However, in the VEWC group, the IOP only normalized by postoperative Day 3. This is interesting to note because Agrawal and Shah reported that IOP was the highest on postoperative Day 1 in a direct cyclopexy treatment. We hypothesize that the additional procedure produced more inflammation in the vicinity of the ciliary body.[20] Besides, trauma may cause dysfunction of the ciliary body, and direct ciliary body damage resulting from cyclopexy could decrease the production of the aqueous again. With the eventual recovery of the ciliary body, the aqueous humor dynamics recovered balance, and both groups showed stable IOP control on postoperative Day 3.

The presence of an IOP spike is common after cyclodialysis and vitrectomy surgery. The mechanisms of hypertension are as follows: As the aqueous drainage channels experience prolonged hypotony, they collapse and cannot immediately allow the aqueous humor outflow when the detached ciliary body is adhered to the spur.[3,4,21] Other possible reasons include acute pupillary block, emulsified oil in the angle, peripheral anterior synechiae, inflammation within the anterior chamber, and shallow anterior chamber.[22,23] After antihypertensive therapy, IOP spikes are mostly under control. In our case series, only one eye with closed globe injury developed glaucoma. This might be due to contusion changes in the trabecular meshwork of the anterior chamber.[24] The likely reasons for postoperative hypotony may have been the dysfunction of the ciliary body despite it being anatomically restored,[25] aphakia,[22] the potentially toxicity of the silicone oil tamponade on the ciliary body,[26,27] and the exposed areas of bare retinal pigment epithelium because of deficient retina that facilitate the absorption of intraocular fluid.[28]

This research has several limitations such as its retrospective nature and the absence of randomization. Despite these limitations, as far as we know, this is the first study comparing VEWOC and VEWC as treatment options for traumatic cyclodialysis clefts with multiple additional ocular comorbidities.

In conclusion, our study showed that vitrectomy with silicone oil endotamponade in itself is an effective method of treating cyclodialysis clefts caused by severe ocular trauma with no additional need to include cyclopexy in the procedure. If the interference of the swinging detached ciliary body is the only concern, surgeons can fix a needle or two to prevent this. The results of this study may help surgeons select the appropriate treatment approach for cyclodialysis cleft closures and reduce the discomfort of long intraoperative times and minimize surgical damages. We plan to perform future studies with larger sample sizes and longer follow-up periods to better evaluate the long-term outcomes of this approach. Furthermore, a prospective, randomized comparative case series study will also be conducted in the future.

Key words: cyclodialysis cleft, cyclopexy, ocular trauma, silicone oil endotamponade, vitrectomy.

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