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Comparing scleral wound suturing and non-suturing in 23-gauge vitrectomy combined with cataract phacoemulsification for the management of proliferative diabetic retinopathy

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Abstract

Purpose To compare the outcomes of scleral wound suturing and non-suturing in 23-gauge vitrectomy combined with cataract phacoemulsification on eyes with severe proliferative diabetic retinopathy.

Methods This retrospective cohort study enrolled patients with proliferative diabetic retinopathy who underwent a 23-step vitrectomy combined with cataract phacoemulsification. Scleral wounds were either sutured or left unsutured in sutured group and unsutured group, respectively. All patients were monitored for 6 months, undergoing slit-lamp examination, intraocular pressure measurement, fundus examination, and vision assessment.

Results A total of 79 eyes were enrolled in sutured group and 85 eyes in unsutured group. Both groups were well-matched for factors such as age, sex, intraocular pressure (IOP), hypertension, diabetes duration, HbA1c levels, visual acuity, retinal detachment, neovascular glaucoma, and preoperative pan-retinal photocoagulation. Despite scleral incision sutures in sutured group, there was no significant difference in surgical time between the groups. Silicone oil and gas tamponade were similarly used, and no significant differences in postoperative complications were found, except that scleral suturing potentially exacerbated conjunctival or scleral scarring. Sutured group had a lower incidence of hypotony, though IOP was not significantly different between groups after one week. For silicone oil tamponade, IOP was comparable between groups, while for gas tamponade, early postoperative IOP was significantly lower in unsutured group. The incidence of postoperative hypotension was higher in unsutured group with gas tamponade. Visual acuity recovery showed no disparity between the groups.

Conclusion For patients with proliferative diabetic retinopathy undergoing vitrectomy combined with cataract surgery, scleral incision suturing appeared to be more effective in maintaining intraocular pressure in the early stage, especially for those who had gas as the vitreous tamponade. However, this might worsened conjunctival or scleral

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scarring. There were no significant differences observed in postoperative complications and visual acuity recovery between patients with and without scleral wound suturing.

Keywords Proliferative diabetic retinopathy, 23-gauge vitrectomy, Scleral wound suturing

Introduction

The International Diabetes Federation (IDF) estimated that the global population with diabetes mellitus (DM) was 463 million in 2019 and projected it to reach 700 million by 2045 [1]. As the most prevalent and specific complication of DM [2], diabetic retinopathy (DR) is also among the primary causes of avoidable blindness in the working-age adult population [3, 4]. With the global population aging rapidly, increased lifespans among those living with DM, lifestyle changes that raised the risk of DM, a heightened burden of DR, and increased demand for eye care and treatment were anticipated [5]. Pars plana vitrectomy (PPV) served as the primary surgical approach for addressing complications associated with diabetic retinopathy, specifically proliferative diabetic retinopathy (PDR), following the exploration of non-surgical options, including pan-retinal laser photocoagulation (PRP) and intravitreal anti-vascular endothelial growth factor (anti-VEGF) injections [6, 7]. Classic indications for PPV include vitreous hemorrhage, severe fibrovascular proliferation leading to tractional retinal detachment (TRD), and tractional rhegmatogenous RDs affecting the macula [8].

Cataracts and PDR often co-occur. With the introduction of modern instrumentation and surgical techniques, the combined approach of cataract extraction and PPV in PDR patients gained popularity in the past few decades [9, 10]. The combined surgery offered several advantages, including enhanced visualization of the posterior segment, improved access to the vitreous base, immediate visual recovery, and eliminated the necessity of cataract surgery in a previously vitrectomized eye [11, 12]. Nevertheless, it presented challenges, including prolonged surgical durations and increased postoperative inflammation. In response to these limitations, various surgical refinements were implemented in clinical practice [13–15]. One of the more commonly adopted techniques involved the simultaneous use of 23-gauge sutureless vitrectomy and cataract surgery [15, 16]. This approach not only saved surgical time but also reduced surgical trauma, leading to a subsequent decrease in postoperative inflammation. Some studies have indicated that [16, 17], compared to traditional 20-gauge vitrectomy with sutures, 23-gauge sutureless vitrectomy could achieve similar therapeutic outcomes while reducing the risk of intraoperative retinal breaks and postoperative neovascular glaucoma in patients with PDR. However, it's essential to consider the potential disadvantages of sutureless vitrectomy surgery, which might encompass an increased incidence of wound leaks, hypotony, choroidal detachment, recurrent vitreous hemorrhage (VH), and more [10, 18–20]. There have been few studies comparing the surgical outcomes, with or without wound suturing, during the performance of 23-gauge vitrectomy combined with cataract surgery in diabetic retinopathy patients. Hence, we initiated this study to evaluate the surgical outcomes of 23-gauge vitrectomy combined with cataract surgery in patients with proliferative diabetic retinopathy, while considering the use of scleral wound suturing. This evaluation encompassed an analysis of postoperative hypotony, recurrent vitreous hemorrhage, elevated postoperative intraocular pressure, and postoperative visual acuity.

Materials & methods

Subjects

This retrospective comparative study involved patients diagnosed with severe proliferative diabetic retinopathy. In both groups, individuals underwent 23-gauge Vitrectomy combined with Cataract Phacoemulsification. Scleral wound suturing or non-suturing was performed in sutured group and unsutured group, respectively. Patients were recruited between January 2018 and December 2023 at Dongyang People's Hospital, China. All patients received detailed consultations regarding the benefits and risks associated with the technique. The study strictly adhered to the principles of the Declaration of Helsinki, and ethical approval was granted by the Institutional Ethics Committee of Dongyang People's Hospital. Informed consent was obtained from all patients. All procedures were performed by a single physician (Gj. Zhao).

Inclusion criteria

- Patients aged 18–80 years diagnosed with severe proliferative diabetic retinopathy.
- Patients who underwent 23-gauge pars plana vitrectomy combined with cataract phacoemulsification for complications like vitreous hemorrhage or tractional retinal detachment.
- Patients with a follow-up period exceeding 6 months after surgery.

Exclusion criteria

- Patients who did not undergo lens removal during vitrectomy.

- Patients who received anti-VEGF intravitreal injections within one week prior to or during surgery.

Surgical procedure

All patients underwent pars plana vitrectomy combined with cataract surgery under retrobulbar anesthesia. The 23-gauge vitrectomy was meticulously performed with conjunctival displacement and an obliquely beveled scleral wound, adhering to the technique described by Eckardt [21]. The vitreous surgery employed a 23-gauge vitreous cutter driven by a vitrectomy unit, specifically utilizing the Stellaris PC (vitreous cutter; Bausch + Lomb, Rochester, NY). The procedure commenced with a scleral tunnel incision and the careful insertion of microcannulas. A clear corneal wound for cataract surgery was strategically created at the 11 o'clock position after the insertion of the microcannulas. Capsulorhexis of the anterior capsule was precisely performed, ensuring its margin covered the edge of a 6.0-mm optic intraocular lens. Following phacoemulsification and the implantation of a folded lens through a 3.0-mm clear corneal wound, complete aspiration of viscoelastic material was conducted. The balanced salt solution, mixed with 1:100,000 epinephrine, was then injected into the anterior chamber to sustain pupil dilation. To prevent anterior chamber collapse during vitrectomy procedures, a prophylactic 10 – 0 nylon suture was thoughtfully placed in the clear corneal wound.

In terms of illumination, a handheld light probe was preferred for focused illumination of posterior pole structures. Bimanual or illuminated instrumentations were deliberately avoided. Instead, the noncontact wide-angle viewing system (BIOM 3; Oculus, Wetzlar, Germany) was employed in nearly all cases. The surgical approach consistently included the complete removal of the posterior vitreous, coupled with extensive shaving of the peripheral vitreous under scleral indentation. The internal limiting membrane was meticulously peeled using indocyanine green or triamcinolone acetonide staining in select cases. Additionally, endolaser photocoagulation was consistently applied to the equator of the retina in almost all cases. For patients who required further intervention, full retinal laser photocoagulation or supplementary laser treatment was performed as needed.

For patients presenting with TRD, intraoperative perfluorocarbon liquid injection, gas-fluid exchange, and gas tamponade or silicone oil tamponade were judiciously performed based on the extent of retinal detachment and the surgeon's experience. Postoperatively, a thorough examination of all sclerotomy sites was conducted, and the decision to suture the scleral incisions was made based on the surgeon's expertise. When suturing was deemed necessary, 8 – 0 polyglactin 910 (Vicryl) with a spatulated needle was used for scleral wound closure.

Outcome measures

- Postoperative visual acuity.
- Intraocular pressure and fluctuations, particularly monitoring hypotony.
- Incidence of postoperative complications.
- Evaluation of scleral wound healing and scarring.

All patients underwent thorough ophthalmological examinations both pre-and post-surgery. The assessments encompassed evaluations of best-corrected visual acuity (BCVA), binocular indirect ophthalmoscopy, non-contact lens slit-lamp biomicroscopy, and fundus photography. Patient medical records were meticulously reviewed, with pre-operative data including age, gender, IOP, hypertension, DM duration, HbA1c levels, preoperative BCVA, presence of RD, presence of neovascular glaucoma (indicated by rubeosis iridis and angle neovascularization), and preoperative pan-retinal photocoagulation.

During postoperative follow-up, we monitored abnormal intraocular pressure IOP changes. Early postoperative hypotony was defined as an IOP below 6 mmHg or a decrease of 10 mmHg, accompanied by choroidal detachment within the first two weeks of the postoperative period. Surgical procedures and postoperative complications were meticulously documented, covering surgical time, utilization of silicone oil tamponade, postoperative cystoid macular edema, postoperative epiretinal membrane, vitreous hemorrhage occurring after 1 month, and newly developed postoperative neovascular glaucoma.

Postoperative follow-up evaluations were conducted at 1 day, 1 week, 1 month, 3 months, and 6 months, primarily documenting intraocular pressure fluctuations, changes in visual acuity, and surgery-related complications.

Statistical analyses.

All statistical analyses were conducted using IBM SPSS Statistics for Windows version 23. Descriptive data between the two groups were compared using either the Mann-Whitney U test or the chi-square test. Group differences in continuous data were assessed using either the Mann–Whitney U test or independent samples t-test. The results are presented as the mean ± standard deviation, and statistical significance was set at a p-value < 0.05.

Results

The study comprised 79 eyes in sutured group and 85 eyes in unsutured group. Table 1 summarizes the preoperative clinical characteristics of both groups. Preoperative patient characteristics were well-matched between

Table 1 Comparison of patient characteristics of all study eyes with PDR at baseline

Group	sutured group	unsutured group	*p* value
Number of eyes	79	85	NA
Age(years)(Mean ± SD)	54.97 ± 9.33	57.22 ± 9.69	0.12[†]
Sex (n), male/female	46/33	58/27	0.18[‡]
IOP(mmHg)(Mean ± SD)	15.83 ± 4.00	15.42 ± 3.80	0.63[†]
Hypertension(%)	47(59.5)	57(67.1)	0.32[‡]
DM duration(years)(Mean ± SD)	9.85 ± 6.89	11.86 ± 7.31	0.09[†]
HbA1c(%),(Mean ± SD)	7.45 ± 0.19	7.83 ± 1.39	0.08[†]
Preop logMAR BCVA(Mean ± SD)	2.11 ± 0.93	2.27 ± 0.91	0.31[†]
Preop RD(%)	22(27.8%)	28(32.9)	0.48[‡]
Preop NVG(%)	13(16.5%)	14(16.5%)	0.99[‡]
Preop PRP(%)	25(31.6%)	17(20.0%)	0.09[‡]

Preop preoperative, RD retinal detachment, NVG neovascular glaucoma, PRP panretinal photocoagulation

[†] *p* values were derived by Mann-Whitney U tests

[‡] *p* values were derived by Pearson's chi-square tests

[§] *p* value was derived by Yates-corrected chi-square test

Table 2 Surgical procedures and postoperative complications

Group	sutured group	unsutured group	*p* value
Surgical time(minutes) (Mean ± SD)	73.29 ± 17.18	72.34 ± 21.01	0.37[†]
Silicone oil tamponade(%)	12(15.2)	21(24.7)	0.13[‡]
Gas tamponade(%)	24(30.4)	31(36.5)	0.41[‡]
Postop EM(%)	6(7.1)	9(10.6)	0.51[‡]
Postop CME(%)	30(35.3)	24(28.2)	0.19[‡]
Postop VH(%)	3(3.5)	2(2.4)	0.93[§]
Postop NVG (%)	7(8.2)	3(3.5)	0.27[§]
Postop hypotony(%)	2(2.5)	11(12.9)	0.03[§]
Dislocation of IOL(%)	2(2.5)	1(1.2)	0.95[§]
Significant conjunctival or scleral scarring(%)	26(32.9)	5(5.9)	0.00[‡]

Postop postoperative, CME cystoid macular edema, EM epiretinal membrane, NVG neovascular glaucoma, VH vitreous hemorrhage, IOL intraocular lens

[†] *p* value was derived by Mann-Whitney U test

[‡] *p* values were derived by Pearson's chi-square tests

[§] *p* values were derived by Yates-corrected chi-square tests

the groups. No statistically significant differences were observed in age, sex, IOP, presence of hypertension, duration of diabetes, HbA1c levels, visual acuity, presence of RD, presence of neovascular glaucoma, and preoperative pan-retinal photocoagulation between the two groups.

Despite the performance of scleral incision suture in sutured group, there was no statistically significant difference in surgical time between the two groups ($P = 0.37$, Table 2). Silicone oil tamponade was applied in 12 eyes (14.1%) in sutured group and 21 eyes (24.7%) in unsutured group, with no statistically significant difference found ($P = 0.13$). Gas tamponade was applied in 24 eyes (30.4%) in sutured group and 31 eyes (36.5%) in unsutured group, with no statistically significant difference found ($P = 0.41$). Cystoid macular edema emerged as the most prevalent postoperative complication, occurring in 30 eyes (35.3%) in sutured group and 24 eyes (28.2%) in unsutured group. Additional complications included the presence of epiretinal membrane in 6 eyes (7.1%) within sutured group and 9 eyes (10.6%) in unsutured group. Notably, vitreous hemorrhage recurred in 3 eyes (3.5%) within sutured group, as opposed to 2 eyes (2.4%) in unsutured group. The onset of neovascular glaucoma was observed in 7 eyes (8.2%) in sutured group and 3 eyes (3.5%) in unsutured group; however, no statistically significant difference in these complications was found between the two groups. Postoperative dislocation of intraocular lens was rare, with 2 eyes in sutured group and 1 eye in unsutured group, which showed no statistically significant difference. Postoperative significant conjunctival or scleral scarring were significantly higher in sutured group than in unsutured group, 26 eyes and 5 eye respectively ($P < 0.05$).

Postoperative hypotony occurred in 2 cases (2.5%) in sutured group and 11 cases (12.9%) in unsutured group (Table 2, $P = 0.03$). None of these hypotonic eyes experienced severe postoperative inflammation. Throughout the postoperative follow-up period, there was a statistical difference in intraocular pressure (IOP) only on the first day after surgery, with no significant difference in IOP between the two groups from one week to six months post-surgery (Fig. 1).

The BCVA before surgery for the two groups was 2.11 ± 0.93 and 2.27 ± 0.91, respectively. One week after surgery, the visual acuity improved to 1.57 ± 0.96 and 1.68 ± 0.99 for the two groups. Over time, both groups showed a gradual improvement in visual acuity. At 6 months post-surgery, the BCVA was 0.89 ± 0.94 for sutured group and 0.97 ± 0.98 for unsutured group. Importantly, there was no statistical difference in the BCVA between the two groups during the follow-up period (Fig. 2).

We conducted a subgroup analysis based on vitreous cavity tamponades. As shown in Fig. 3a, there was no significant difference in postoperative intraocular pressure between sutured group and unsutured group patients who had silicone oil chosen as the vitreous tamponade. In Fig. 3b, it showed that in patients who had gas chosen as the vitreous tamponade, the early postoperative intraocular pressure (on postoperative day 1 and week 1) in unsutured group was significantly lower than that in sutured group. In unsutured group, only 9.5% of patients with silicone oil tamponade experienced postoperative hypotony, which was significantly lower than the 22.6% observed in patients with gas tamponade.

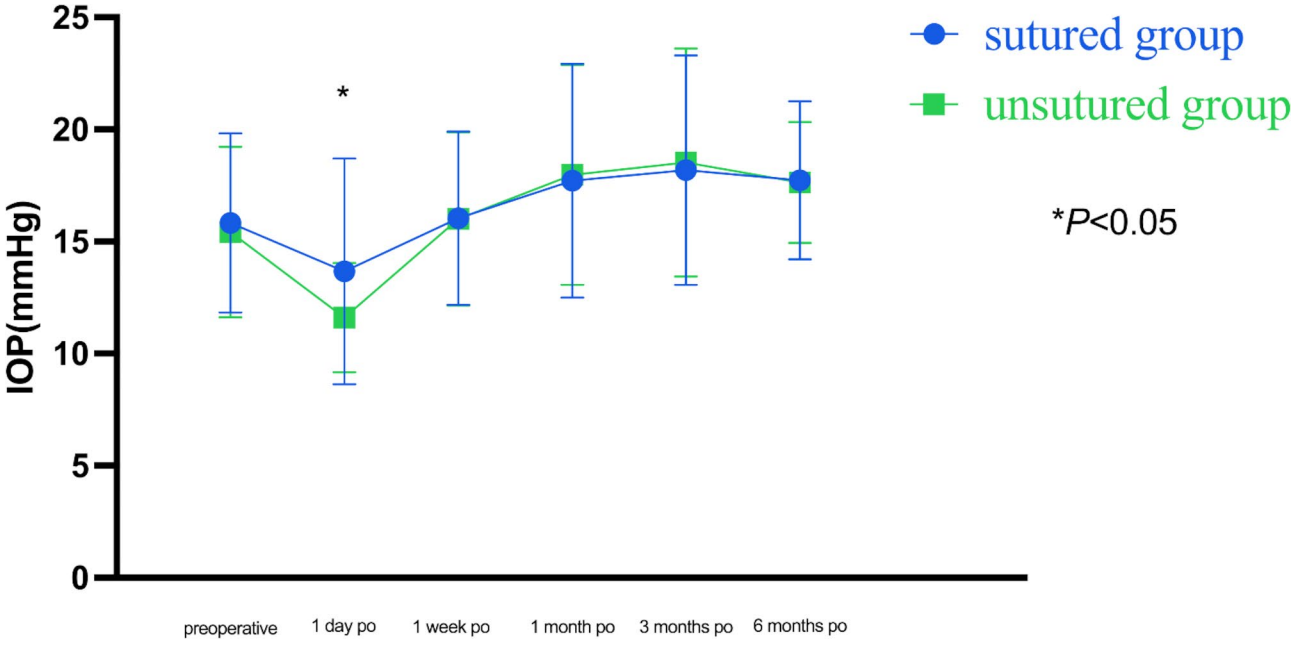

Fig. 1 Changes in IOP from baseline to 6 months were assessed. *Statistically significant

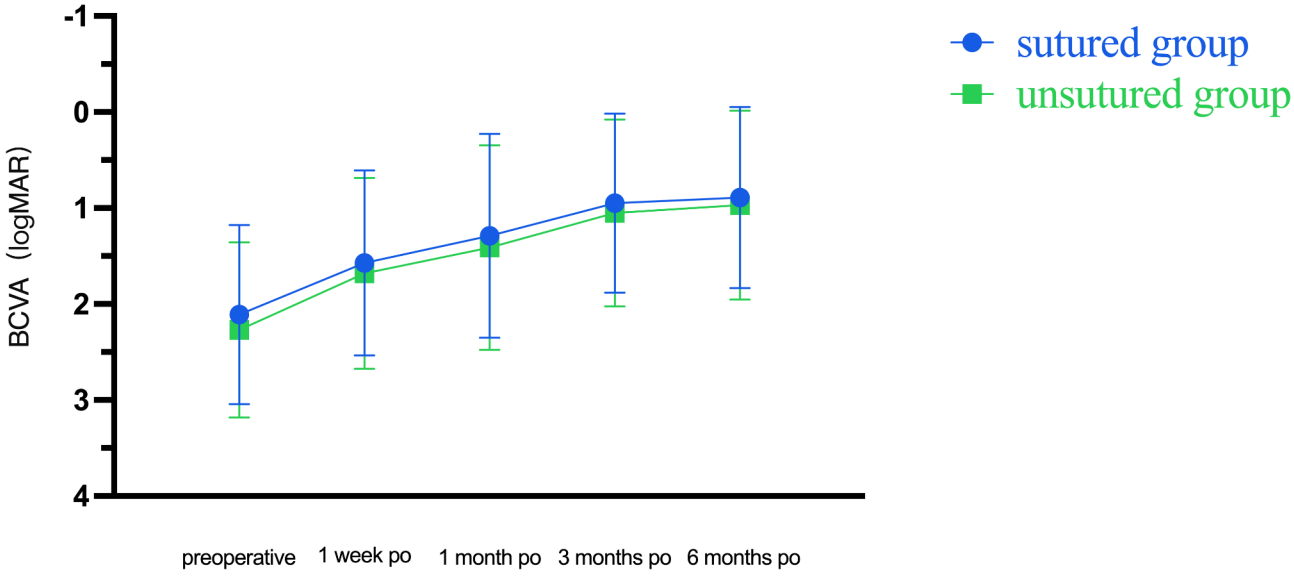

Fig. 2 Changes in visual acuity from baseline to 6 months were assessed, and no statistical difference in BCVA was observed between the two groups during the follow-up period

Discussion

In 2002, Fujii et al. [22] introduced an innovative 25-gauge instrument system for transconjunctival sutureless vitrectomy surgery. This system proved particularly suitable for cases that did not necessitate the full capabilities of conventional vitrectomy due to its lower infusion and aspiration rates. In 2005, Eckardt [21] introduced a 23-gauge instrument system to broaden its applications, addressing the limitations posed by the excessive flexibility of 25-gauge instruments in handling all tasks during intricate vitrectomy procedures.

The advancement of modern instrumentation and surgical techniques has led to a notable rise in the prevalence of combined cataract and vitreoretinal surgeries. Recently, the effectiveness and safety of the combined approach involving phacoemulsification and 23-gauge sutureless vitrectomy have been demonstrated in managing concurrent cataracts and various vitreoretinal diseases, including PDR [15, 20, 23]. The implementation of combined 23-gauge sutureless vitrectomy and

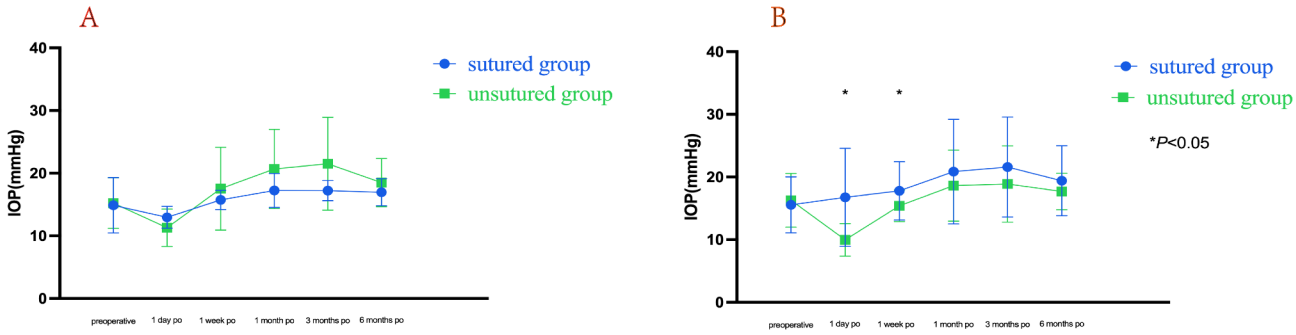

Fig. 3 Changes in IOP from baseline to 6 months postoperative in the two groups of patients with different vitreous cavity tamponades: (**a**) patients with silicone oil tamponade, (**b**) patients with gas tamponade

cataract phacoemulsification in patients with proliferative diabetic retinopathy has shown notable advantages, including expedited visual rehabilitation, diminished conjunctival fibrosis, a decreased occurrence of intraoperative retinal breaks, and a lower risk of postoperative neovascular glaucoma [12, 16, 17]. Nevertheless, these findings are primarily in comparison to conventional 20-gauge vitreous surgery. Currently, there is a lack of studies comparing the distinctions within 23-gauge vitreous surgery for proliferative diabetic retinopathy, specifically regarding whether the scleral incision is sutured or left unsutured. Moreover, it is crucial to consider potential drawbacks associated with sutureless vitrectomy surgery, including complications such as endophthalmitis, wound leakage, hypotony, retinal detachment, choroidal detachment, and intraocular hemorrhage [18, 24, 25].

In this study, patients who did not undergo scleral suturing exhibited a higher occurrence of hypotony and a reduced IOP on the first day following surgery. However, it is important to note that hypotony might contribute to increased inflammation, potentially elevating the risk of complications such as postoperative hemorrhage, cystoid macular edema, and the formation of the epiretinal membrane. Despite these concerns, our follow-up assessments revealed no statistically significant differences in postoperative complications between the two groups. This observation could be attributed to the ability of unclosed scleral wounds to self-close within a short timeframe, supported by the absence of a noteworthy IOP difference between the two groups one week after surgery. Previous studies have documented that transient post-operative hypotony varied from 14.28 to 26.6% in 23-gauge transconjunctival sutureless vitrectomy [20, 26]. In our current study, transient post-operative hypotony was observed in 11 eyes (12.9%) in the sutureless group. A significant contributor to our lower hypotony incidence is our definition, where we considered an IOP of less than 6 mmHg as hypotony, in contrast to previous studies that used a threshold of less than 10 mmHg. In unsutured group, the incidence of postoperative hypotony was higher when gas was used as the vitreous tamponade, while it was relatively lower when silicone oil was used. This could be related to the higher viscosity and more stable volume of silicone oil as a tamponade. This suggests that for such patients, when choosing gas as a vitreous tamponade, measures such as scleral incision suturing or covering with a compression bandage should have been considered to prevent postoperative hypotony. In fact, in two cases within the unsutured group, persistent hypotony lasting more than three days prompted secondary scleral suturing as an additional intervention. In the unsutured group, no silicone oil leakage was observed, despite the theoretical risk of leakage with silicone oil tamponade. This was likely due to the self-sealing properties of the scleral wounds and careful surgical technique. All sclerotomy sites were checked postoperatively, and sutures were applied if leakage was detected.

Prior research [16] indicated a potential rise in the occurrence of postoperative neovascular glaucoma associated with the use of absorbable sutures during sclerotomy. In our study, despite the utilization of absorbable sutures, we found no significant disparity in postoperative neovascular glaucoma between the two groups. This observation might be attributed to the simultaneous lens removal for all patients during vitrectomy in both groups, facilitating the administration of thorough retinal laser therapy and consequently diminishing the likelihood of postoperative neovascular glaucoma. However, when performing scleral incision suturing, more noticeable conjunctival or scleral scarring occurred postoperatively. This could have been related to the irritation caused by the sutures to the conjunctiva and sclera, which exacerbated the local inflammatory response.

In addition to the benefits of reduced surgical trauma and faster recovery, the authors suggest that 23-gauge vitrectomy without sutures may offer potential advantages in cases where future filtration surgery, such as glaucoma surgery, is required. The absence of sutures could reduce the formation of adhesions and scarring, potentially improving the surgical field for future procedures and

contributing to a smoother postoperative recovery. This may be particularly advantageous in minimizing complications and facilitating better outcomes in subsequent filtration surgeries. However, further studies are needed to fully evaluate the long-term impact of sutureless vitrectomy on future glaucoma surgeries and other related procedures.

The predominant postoperative complication in our study was macular edema, identified through Optical Coherence Tomography in 35.3% of individuals in sutured group and 28.2% in unsutured group. Our figures indicate higher rates compared to those reported in other studies, where postoperative macular edema was identified in 10.3–26% of eyes undergoing combined surgery for PDR [10, 27]. The primary reason for this might be that our study excluded patients who had received anti-VEGF intravitreal injections within one week before or during surgery. Administering anti-VEGF injections before vitrectomy in patients with PDR had the potential to streamline the surgical procedure and reduce postoperative complications, such as macular cystoid edema [28, 29].

Conclusions

In summary, for patients undergoing vitrectomy combined with cataract surgery for proliferative diabetic retinopathy, it seems that scleral incision suturing is more effective in preserving intraocular pressure during the early stages. Nevertheless, no significant differences were noted in postoperative complications and visual acuity recovery between patients who underwent scleral wound suturing and those who did not. Additionally, significant postoperative hypotony in the early stages can be attributed not only to the non-suturing of scleral incisions but also to the use of gas tamponade, both of which should be carefully considered in postoperative management.

This study possesses several limitations. It was a retrospective, nonrandomized investigation conducted in a single hospital. Furthermore, the decision to suture the scleral incisions was based on the individual preferences of the surgeons. The preoperative cataracts were not graded, and refractive outcomes were not measured, owing to the retrospective nature of the study. Additionally, we couldn't exclude the presence of preoperative macular edema in cases where poor visualization was due to VH, potentially leading to an overestimation of postoperative macular edema. Given the limited number of study participants, larger-scale studies are essential to validate and extend the findings of this research.

Abbreviations

anti-VEGF	Anti-vascular endothelial growth factor
BCVA	Best-corrected visual acuity
DM	Diabetes mellitus
DR	Diabetic retinopathy
IDF	Diabetes Federation
IOP	Intraocular pressure
PDR	Proliferative diabetic retinopathy
PPV	Pars plana vitrectomy
PRP	Pan-retinal laser photocoagulation
TRD	Tractional retinal detachment
VH	Vitreous hemorrhage

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Author contributions

WHY conceptualized and designed the study. ZHS drafted the main manuscript text. WHY collected the data, and ZGJ verified it. ZHS conducted the statistical analyses. All authors critically reviewed and revised the manuscript before submission.

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Data availability

Due to privacy concerns related to patient information, the data are not publicly accessible. However, interested parties may request access to the data from the corresponding author through reasonable inquiries.

Declarations

Ethics approval and consent to participate

The study strictly adhered to the principles of the Declaration of Helsinki, and ethical approval was granted by the Institutional Ethics Committee of Dongyang People's Hospital. Informed consent was obtained from all patients.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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