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RETINAL DISORDERS

Influence of sutureless 23-gauge sclerotomy architecture on postoperative intraocular pressure decrease: results of a multivariate analysis

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Abstract
Purpose To evaluate the factors affecting the postoperative intraocular pressure (IOP) decrease in 23-gauge (23-G) sutureless vitrectomy, including incision architecture evaluated by anterior segment spectral-domain optical coherence tomography (SD-OCT).
Methods A prospective cohort study of 43 patients who underwent primary transconjunctival 23-G pars plana vitrectomy. All sclerotomy wounds were imaged 1 day after surgery using the anterior segment module of SD-OCT (OCT Spectralis, Heidelberg Engineering, Heidelberg, Germany). 23-G sclerotomy architecture, preoperative and postoperative medical data were also prospectively collected.
Results Multivariate logistic regression analysis, with backward elimination, found that surgery duration (adjusted OR=9.17, p=0.020) and loss of wound apposition (adjusted OR=15.12, p=0.022) were risk factors for significant postoperative IOP decrease (≥3 mmHg) 1 day after surgery; while age, gender, myopia, and gas tamponade were not risk or protective factors for postoperative IOP decrease.
Conclusions In 23-G pars plana vitrectomy, the early postoperative decrease in IOP is mainly influenced by surgery duration and the self-sealing nature of the sclerotomy. The IOP decrease was not influenced by the presence or the absence of gas tamponade.

Keywords Sutureless 23-G vitrectomy · Post-operative intraocular pressure decrease · Multivariate analysis · Sclerotomy architecture · Anterior segment optical coherence tomography · Spectral domain

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Introduction

Transconjunctival sutureless vitrectomy provides several advantages over traditional 20-gauge (20-G) vitrectomy, including faster wound healing, less conjunctival scarring, improved patient comfort, less intraocular inflammation, reduced surgically induced astigmatism and decreased operating time [1–7]. However, early postoperative hypotony and potential wound leakage remain concerns accompanying the use of sutureless vitrectomy.

Using multivariate analysis, some authors have evaluated the risk factors associated with sclerotomy leakage and postoperative hypotony in 23-G sutureless pars plana vitrectomy, and have suggested the creation of oblique or beveled sclerotomy incisions, assumed to be self-sealing, in order to reduce the risk of wound leakage, postoperative hypotony, and endophthalmitis [8, 9]. However, these studies did not investigate the in vivo architecture of the sutureless vitrectomy incision, and therefore did not include these parameters in the multivariate analysis. Moreover, none of them evaluated the early postoperative decrease in intraocular pressure, which is more relevant to evaluating the consequences of wound leakage, and may be the only hint of this type of complication.

We are unaware of prior investigations using anterior segment spectral-domain optical coherence tomography (SD-OCT) to evaluate the influence of sclerotomy wounds architecture on postoperative IOP decrease. The purpose of this prospective study was to evaluate, in a stepwise logistic regression analysis, the influence of sutureless 23-G sclerotomy architecture on the postoperative IOP decrease, considering other clinical factors such as gas tamponade and surgery duration.

Patients and methods

Subjects

Between July 2010 and October 2010, patients with various vitreoretinal diseases treated using primary transconjunctival 23-G sutureless pars plana vitrectomy were consecutively included in the study. Patient diagnosis categories were split into two broader categories. Macular diagnoses were defined as surgeries for epiretinal membrane removal, vitreomacular traction syndrome, or macular hole repair. Nonmacular diagnoses were defined as surgeries for rhegmatogenous retinal detachment, tractional retinal detachment, proliferative diabetic retinopathy, and dislocated lens. Patients with a history of prior scleral buckling, pars plana vitrectomy (PPV), or presence of conjunctival or scleral scarring and other coexisting ocular disorders such as glaucoma and uveitis were not included in the study. We also did not include patient who needed combined cataract extraction. Patients were operated on by two experienced vitreoretinal surgeons (R.A. and C.M.) using the same surgical technique at the Quinze-Vingts National Ophthalmology Center (Paris, France).

This study was approved by the Ile-de-France Institutional Review Board for Human Subjects Research (CCP 5, N° 10793), and the study adhered to the tenets of the Declaration of Helsinki. Informed consent was obtained from all the eligible patients before operations.

Surgical procedure

All patients underwent three-port pars plana vitrectomy with the Alcon 23-G trocar/cannula microvitrectomy system (Alcon Laboratories Inc., Fort Worth, TX, USA) under peribulbar anesthesia. The conjunctiva and the Tenon capsule were anteriorly displaced away from the intended sclerotomy site, using forceps in order to avoid direct communication between entry sites. All incisions were made by inserting trocars first at an oblique angle between 20° and 30° tangential to the scleral surface, 3.5 mm posterior to the corneoscleral limbus, with the bevel up. Once reaching the trocar sleeve, the cannula was rotated 90° perpendicular to the globe toward the midvitreous cavity. The cuff of the cannula was held in place by forceps, and the trocars were removed from the eye. The infusion cannula was placed in the inferotemporal quadrant, while the two other cannulas were placed in the superotemporal and superonasal quadrants. All vitrectomies were performed with the Accurus vitrectomy system and Accurus cutters with speeds up to 2500 cuts per minute (Alcon Laboratories, Inc.). Following the vitrectomy procedure, patients underwent when needed a gas–fluid exchange based on the surgical indication. In cases that required internal tamponade, intravitreal air, or gas [sulfurhexafluoride (SF_6; 20 %) hexafluoroethane (C_2F_6; 16 %) perfluoropropane (C_3F_8; 14 %)] injection was performed. At the end of surgery, the cannulas were withdrawn from the sclera and the conjunctiva was pushed posteriorly with a cotton tip for all sclerotomies. The infusion line was clamped at the time the cannulas were removed and unclamped afterwards. Firm pressure was applied with a cotton-tip applicator onto the sclerotomy sites to enhance sclerotomy sealing and to return the displaced conjunctiva to its original position. A cellulose sponge (Weck-Cel; Medtronic Xomed Inc, Jacksonville, FL, USA) was applied to the sclerotomy site to identify any vitreous wick. Each of the wounds was then carefully inspected for leakage indicated by the formation of subconjunctival bleb or hypotony. If leakage was noted, further pressure was applied with a sterile cotton-tipped applicator to the site until leakage ceased. If leakage continued beyond 1 min, a Vicryl 7–0 (polyglactin 910, Ethicon Inc, Somerville, NJ, USA) suture was performed to close the scleral wound after a small opening of the conjunctiva. Patients who needed suture of one of their incisions were excluded from the analysis.

None of the patients had a hypotensive treatment during the first postoperative month.

Optical coherence tomography (OCT)

OCT examinations were performed 1 day after surgery by a single examiner (R.T.). The sclerotomy wounds were imaged with the non-contact anterior segment module of SD-OCT (OCT Spectralis, Heidelberg Engineering, Heidelberg, Germany) with an axial resolution of 7 μm, and transverse resolution of 14 μm. The beam was carefully aligned to scan across the pars plana region to traverse the center of the incisions, and rotated parallel to the limbus to follow the paths of the incisions. Two-dimensional images were captured when the whole tract was displayed in a cross-sectional profile.

Image analysis (Fig. 1)

The incision angle was measured using ImageJ software (version 1.43u). The angle subtended from the scleral tunnel to the tangent line of the sclera defined the incision angle. Other incision characteristics were also examined including evidence wound gaping (either externally or internally), misalignment of the roof and floor of the incision, local ciliochoroidal detachment, and vitreous incarceration. Loss of wound apposition was defined by the presence of wound gaping or misalignment of the roof and floor of the incision.

Outcome measures

Preoperative, intraoperative, and postoperative medical data were prospectively collected. The data collected included: (1) patient age, gender, eye laterality, diagnosis, preoperative refractive error, preoperative and postoperative best-corrected visual acuity (BCVA; measured with the Snellen visual acuity chart and converted into logarithm of the minimum angle of resolution (LogMAR)) at 1 month, (2) preoperative and postoperative intraocular pressure (IOP; measured with the Goldman applanation tonometer) at 1 day, 1 week, and 1 month following surgery, (3) duration of the surgery (defined as the time between insertion and removal of the lid speculum), (4) wound self-sealing (evaluated using anterior segment module of SD-OCT; see above for more details), and (5) intraoperative and postoperative complications [including severe hypertony (IOP$>$30 mmHg) or hypotony (IOP$<$6 mmHg), suprachoroidal hemorrhage, retinal tear, retinal detachment, vitreous hemorrhage, and endophthalmitis]. A significant postoperative decrease in IOP was defined as a 3-mmHg or greater decrease in IOP from the preoperative level.

Statistical analysis

Results are presented as mean ± standard deviation (SD) for continuous variables and as proportions (%) for categorical variables. Univariate comparisons by logistic regression were performed to identify associations between a significant postoperative decrease in IOP at 1 day and other variables under study. Variables found to be associated with a P-value of less than 0.20 were then subjected to a multivariate logistic regression, with backward elimination. In order to handle interaction effects, we added interaction terms to the last step model as cross-products of the standardized independent variables. Preoperative refractive error was dichotomized to more than −3 diopter and less than −3 diopter. Surgical duration was dichotomized to up to 45 min and more than 45 min. P-values of 0.05 or less were considered statistically significant. Statistical analysis was carried out using SPSS for Windows version 16.0 (SPSS, Inc., Chicago, IL, USA).

Results

General characteristics

Between July 2010 and October 2010, 52 patients with various vitreoretinal diseases were treated using primary transconjunctival 23-G sutureless pars plana vitrectomy. Among them, 44 patients met the inclusion criteria. One patient was excluded from analysis because he needed suture of at least one of his sclerotomies. Details of patient selection are described in Fig. 2.

Forty-three eyes of 43 patients (20 males and 23 females) were finally included for analysis. The mean patient age was 65.05±12.83 years. The mean surgical time was 38.79± 18.67 min. Twenty-one patients underwent macular surgery, while 22 patients underwent nonmacular surgery. The indications for 23-G vitrectomy are shown in Table 1.

The mean preoperative BCVA (LogMAR) was 1.21± 0.73. One month after surgery, the mean BCVA was 0.55± 0.29. The mean IOP decreased from 14.67±2.84 mmHg preoperatively to 13.51±3.72 mmHg on the first day postoperatively. One week and 1 month after surgery, the mean IOP returned to baseline levels (Table 2). No severe postoperative hypotony or hypertony occurred in this study.

OCT findings

Seventeen eyes (39.5 %) exhibited at least one external or internal incision gaping. Ten eyes (23.3 %) exhibited misalignment of the roof and floor of incisions. In all, 20 eyes (46.5 %) exhibited loss of wound apposition (defined by the presence of wound gaping or misalignment of the roof and

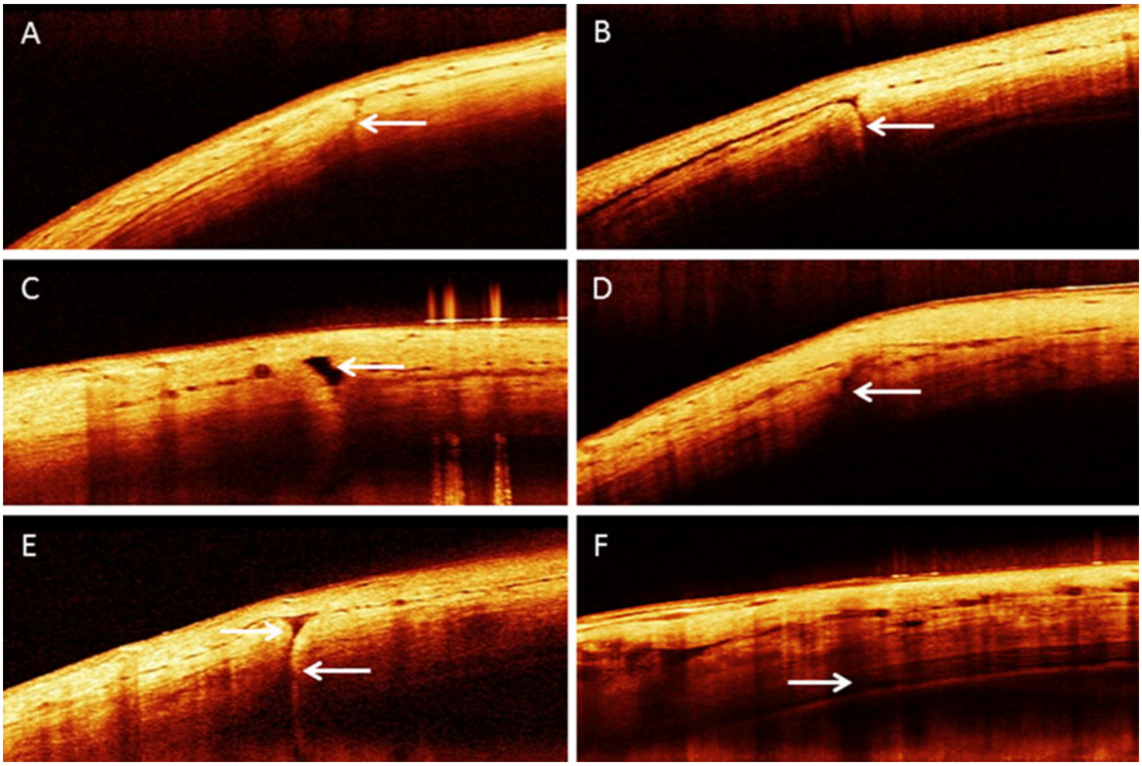

Fig. 1 Spectral-domain optical coherence tomography images showing different incision angles, examples of absence of good apposition, and other complications. **a** Oblique incision (60°). **b** Straight incision (90°). **c** External gaping. **d** Internal gaping. **e** Misalignment of the incision roof and floor. **f** Local ciliochoroidal detachment

floor of the incision). Eleven eyes (25.6 %) exhibited at least one incision angle more than 60°. Vitreous incarceration and ciliochoroidal detachment were detected in seven (16.3 %) and six eyes (14 %) respectively.

Fig. 2 Flow diagram showing the selection process of patients under study

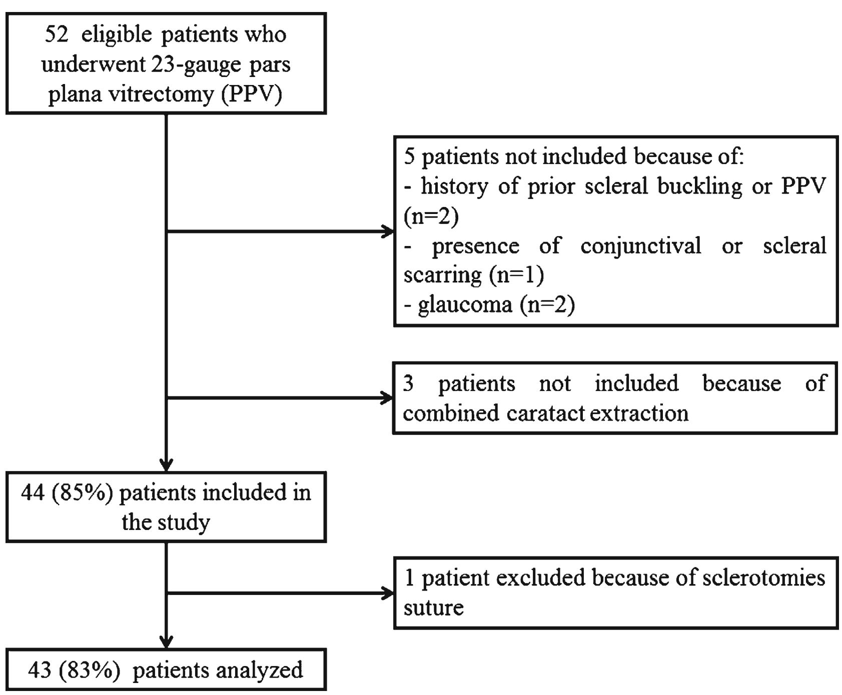

Table 1 Indications for 23-G vitrectomy

Indications	*N* (%)
Epiretinal membrane	19 (44.2)
Macular hole	1 (2.3)
Vitreomacular traction	1 (2.3)
Rhegmatogenous retinal detachment	13 (30.2)
Tractional retinal detachment	6 (14.0)
Proliferative diabetic retinopathy	2 (4.7)
Dislocated lens	1 (2.3)

Factors associated with a significant postoperative decrease in IOP 1 day after surgery

Univariate and multivariate logistic regression analyses were carried out to determine relations between a significant postoperative decrease in IOP 1 day after surgery and clinical features and surgical details of 23-G vitrectomy (Table 3). Nonmacular diagnosis (OR=24, p=0.004), surgical duration more than 45 min (OR=21.67, p=0.0003), loss of wound apposition (OR=33, p=0.002), presence of at least one gaping incision (OR=22, p=0.0005) or at least one incision angle >60° (OR=4.29, p=0.042), and presence of misalignment of the roof and floor of incisions (OR=22.4, p=0.0008) were significant risk factors for a significant postoperative IOP decrease 1 day after surgery (Table 3). Gas tamponade was found to be a protective factor (OR=0.42), but the relation was not significant (p=0.271).

Variables found to be associated with a P-value lower than 0.20 (i.e., gender, diagnosis, preoperative BCVA, surgical duration, incision gaping, one incision angle >60°, misalignment of the roof and floor of incision, wound apposition, and vitreous incarceration) were then included in a multivariate logistic regression analysis, with backward elimination in order to identify the best model (Table 4). In the last step model, surgery duration (adjusted OR=9.17, p=0.020) and loss of wound apposition (adjusted OR=15.12, p=0.022) remained statistically significant risk factors for a significant postoperative decrease in IOP 1 day after surgery. Further analysis did not show an interaction between these two factors.

Complications

No complications occurred in this study.

Discussion

Although wound construction is an important factor preventing postoperative leakage in sutureless vitrectomy [4, 8, 10, 11]; there are currently no studies evaluating the direct relation between in-vivo sclerotomy architecture and postoperative IOP decrease considering other clinical factors in a multivariate analysis. In this study using an anterior segment SD-OCT module, we demonstrated with logistic regression that integrity of wound architecture and surgical duration are probably the most determinant factors for postoperative IOP decrease.

In the present study, we used the anterior segment module adapted to the Spectralis SD-OCT device to evaluate the wound architecture. We found an association between the postoperative IOP decrease and the wound architecture evaluated by OCT. IOP decrease was greater in cases of incision gaping or misalignment of the incision roof and floor. These findings are consistent with those of previous reports. Chen et al. evaluated sutureless vitrectomy incision architecture in the immediate postoperative period using Visante OCT, and found that IOP was significantly higher in eyes with good wound apposition as opposed to those with loss of wound apposition [10]. An increased risk of transient postoperative hypotony has been reported with straight transconjunctival incisions, while an oblique incision was associated with a lower incidence of postoperative hypotony [8]. Lopez-Guajardo et al. performed in-vivo ultrasound biomicroscopy (UBM) on direct and oblique 25-G sclerotomies, and showed that conjunctival blebs developed over 64 % of direct incisions and 25 % of oblique incisions, but all resolved spontaneously by day 15 [12].

These findings are similar to those observed after sutureless clear corneal incisions. Our team had studied corneal incisions using anterior segment optical coherence tomography, and found that straight and remodeled corneal incisions were associated with an increased risk of leakage, hypotony, and infection [13]. As for corneal incisions in cataract surgery, an oblique sclerotomy can reduce the risk of endophthalmitis because of the valve phenomenon, the internal lip press against the outer lip through IOP, thereby helping the closure of the wound and reducing the risk of leakage, hypotony, and infection. The apposition of the sclerotomy edges increases as IOP increases.

In the present study, we did not find a statistical association between age and postoperative IOP decrease. Various

Table 2 Intraocular pressure value (IOP; mmHg) at the different points of the study

Intraocular pressure (mmHg)	Preoperative	One day after surgery	One week after surgery	One month after surgery
Mean	14.67	13.51	14.47	14.81
Standard deviation	2.84	3.72	2.56	2.85

Table 3 Univariate logistic regression analysis for associations between clinical factors and significant decrease of intraocular pressure (IOP) 1 day after surgery

Factors	Significant decrease of IOP 1 day after surgery (%)	Odds ratio	95 % CI	*P*-value
Gender				
Male	8/20 (40)	2.40	0.63–9.12	**0.199**
Female	5/23 (21.7)			
Age at surgery (years)	____	1.00	0.95–1.06	0.892
Laterality				
Left	7/22 (31.8)	1.17	0.32–4.30	0.817
Right	6/21 (28.6)			
Preoperative refractive error (diopter)				
≤ −3	4/11 (36.4)	1.46	0.34–6.23	0.609
> −3	9/32 (28.1)			
Preoperative best corrected visual acuity (LogMAR)	____	2.32	0.90–5.95	**0.073**
Gas tamponade				
Yes	2/11 (18.2)	0.42	0.08–2.31	0.322
No	11/32 (43.4)			
Diagnosis				
Nonmacular	12/22 (54.5)	24	2.72–211.51	**0.004**
Macular	1/21 (4.8)			
Surgical duration				
>45 min	10/14 (71.4)	21.67	4.10–114.50	**0.0003**
≤45 min	3/29 (10.3)			
Incision gaping				
Yes	11/17 (64.7)	22	3.81–126.88	**0.0005**
No	2/26 (7.7)			
Misalignment of incision roof and floor				
Yes	8/10 (80)	22.4	3.64–138.02	**0.0008**
No	5/33 (15.2)			
Loss of wound apposition				
Yes	12/20 (60)	33	3.68–296.00	**0.002**
No	1/23 (4.3)			
One incision angle >60°				
Yes	6/11 (54.5)	4.29	1.0–18.32	**0.042**
No	7/32 (21.9)			
Local ciliochoroidal detachment				
Yes	3/6 (42.9)	2.70	0.47–15.65	0.268
No	10/37 (27.9)			
Vitreous incarceration				
Yes	4/7 (57.1)	4.0	0.75–21.38	**0.105**
No	9/36 (25)			

CI confidence interval

The values in bold indicate association with a *P*-value lower than 0.20

studies have reported that young age could predispose toward wound leakage and postoperative hypotony [9, 14]. However, the cause of higher leakage rates in younger patients was more likely because of their preoperative

Table 4 Multivariate logistic regression analysis (*n*=43)

Factors	Adjusted odds ratio	95 % CI	*P* value
Surgical duration (>45 vs ≤45 min)	9.17	1.43–58.99	0.020
Loss of wound apposition (yes vs no)	15.12	1.47–155.49	0.022

CI confidence interval

diagnosis and surgical durations, as suggested by Lin et al. Young patients often had a nonmacular diagnosis and longer surgical durations, whereas older patients often had a macular diagnosis and shorter surgical durations [8]. Lin et al. reported that a patient's young age was a significant risk factor of wound leakage in the univariate analysis; however, the multivariate analysis suggested age was a confounding variable [8].

Woo et al. reported that myopia, defined as an axial length ≥ 25 mm, was associated with postoperative hypotony after 23-G sutureless vitrectomy [9]. They argued that the abnormal architecture of scleral tissue in myopic eyes could be associated with poor wound sealing and postoperative hypotony. In the present series, there was no association between preoperative refractive error and IOP decrease. The difference may first be due to the fact that we only measured preoperative refraction and not axial length. Second, we did not have a large proportion of high myopia in this series: the univariate analysis was designed for preoperative refractive error −3 diopters or less and greater than −3 diopters; other limits made the statistical analysis unstable.

Ciliochoroidal detachment after sutureless vitrectomy on postoperative day 1 varies in incidence from 2.7 % to 11.4 % according to different reports [4, 10, 15, 16]. In the present series, six of 43 eyes (14 %) presented a local ciliochoroidal detachment, as detected by SD-OCT. Chen et al. found that the mean IOP was significantly lower in eyes with local ciliochoroidal detachment than in those without it [10]. In our study, the presence of a ciliochoroidal detachment tended to be related to IOP decrease on postoperative day 1 with an OR=2.7, but the association was not significant.

The role of internal tamponade with air or gas in the dynamics of the incision and the postoperative IOP change is still controversial. Ho et al. investigated IOP after 23-G and 25-G pars plana vitrectomy randomized to fluid versus air fill, and found no difference in the mean IOP for eyes undergoing 23-G pars plana vitrectomy randomized to fluid versus air filling [17]. In our study, which only included patients who underwent 23-G pars plana vitrectomy, the presence of gas tamponade was not a significant protective factor for postoperative IOP decrease. In fact, the role of air or gas tamponade in preventing leakage has been mainly reported after 25-gauge vitrectomy, and has been explained by the surface tension, which rises at the gas–fluid interface and tends to reduce leakage in gas-filled eyes [11, 17–20].

The present study had a number of potential limitations. First, although this study was prospective, the patients were not randomly assigned, as the choice of surgery was dictated by the disease. Second, this study investigated a small number of patients. Third, the OCT examination was not repeated so as to evaluate the differences of scleral wound closure.

In conclusion, we found using multivariate analysis that postoperative IOP decrease mainly depends on sclerotomy integrity and surgical duration. Thus, we emphasize the need for rigorous construction of oblique incisions, and advocate meticulous examination of incisions at the end of surgery, especially in conditions associated with increased risk of leakage such as long and complex surgery. Surgeons should not hesitate to suture the sclerotomy if leakage is present. These identified factors are likely to act in severe postoperative hypotony; however, more investigations are needed to confirm this hypothesis. Further prospective studies with larger series and longer follow-up are also needed to evaluate the influence of wound-closure process on postoperative IOP variation.

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Conflict of interest None

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