Int Ophthalmol (2022) 42:1763–1769
https://doi.org/10.1007/s10792-021-02172-7

ORIGINAL PAPER

Intraocular pressure outcomes after 23-G vitreoretinal surgery with two different transconjunctival sutureless sclerotomy techniques: vertical versus tunnel entry

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Received: 28 June 2021 / Accepted: 18 December 2021 / Published online: 26 January 2022

Abstract

Purpose Comparison of postoperative intraocular pressure (IOP) course and early complications in 23-gauge (23-G) pars plana vitrectomy (PPV) using vertical entry sclerotomy and scleral tunnel sclerotomy in uncomplicated rhegmatogenous retinal detachment (RRD).

Method A prospective, randomized, comparative, interventional clinical trial of 103 23-G vitrectomy cases using two different transconjunctival sutureless sclerotomy techniques performed by a single vitreoretinal surgeon for uncomplicated RRD. Fifty-two eyes underwent PPV using a three-port 23-G single stage, vertical trocar entry without creating a scleral tunnel (Group 1), while in 51 eyes, a two-stage, oblique trocar entry with creation of a scleral tunnel was performed (Group 2). Sulfur hexafluoride (SF6) gas (20%) was used in all cases as a buffer. Intraocular pressure measurements and detailed biomicroscopic examination of the groups were recorded on the postoperative first day, first week, and first month. Visual acuity and fundoscopic examinations were recorded at one month. The effects of the two methods on postoperative intraocular pressure and early complications were compared.

Results There was no significant difference between the two groups in terms of age and gender ($p > 0.05$). The mean postoperative intraocular pressure on the first day was 15.06 ± 3.71 for Group 1 and 16.14 ± 3.09 mmHg for Group 2. The lowest recorded IOP was 6 mmHg. Postoperative visual acuity did not differ between the two groups ($p > 0.05$). In addition, IOP values did not differ statistically between the two groups ($p > 0.05$). In both groups, the mean IOP values measured at different intervals did not differ statistically ($p > 0.05$).

Conclusion There was no significant difference in terms of postoperative IOP between vertical entry 23-G sclerotomy and 23-G tunnel entry sclerotomy for PPV with 20% SF6 tamponade surgery.

Keywords Intraocular pressure and 23G vitrectomy · Vertical sclerotomy · Tunnel entry sclerotomy · SF6 tamponade · Surface tension · Rhegmatogenous retinal detachment

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Introduction

Modern vitrectomy surgery was first performed with 20 gauge instruments. In recent years, there is an increasing trend toward smaller gauge instruments and different insertion techniques for sclerotomy (wound construction) in pars plana vitrectomy (PPV) [1]. Following the introduction of the microincisional vitrectomy system (MIVS), different studies have been performed with 25-G, 23-G and, in recent years, 27-G instrumentation [2–5]. In 1996, Chen [6] introduced self-sealing sclerotomies using scleral flaps for a 20-G sutureless vitrectomy technique, Fujii et al. [2, 3] introduced a 25-G sutureless vitrectomy in 2002, and Eckardt [4] introduced the 23-G sutureless vitrectomy in 2005. Finally, Oshima et al. [5] introduced a 27-G sutureless vitrectomy in 2010. Sutureless surgical techniques in PPV afford shorter operation time, decreased inflammation and faster recovery time, improved patient comfort, less conjunctival scaring, and decreased postoperative astigmatism. Despite the advantages of the sutureless technique, there are also reported complications related to wound leakage, such as postoperative hypotonia, choroidal detachment, and increased incidence of postoperative endophthalmitis [7, 8].

In 25-G vitrectomy, although the remaining incisions in the sclera are small enough to close on their own without suturing, these instruments are too flexible for many of the complicated tasks performed on the retina and vitreous body. To combat this, Eckardt [4] presented a transconjunctival sutureless method for 23-G vitrectomy in which he described the creation of a scleral tunnel in two stages. Although this is effective with regard to postoperative hypotonia and other complications of wound leakage, it can sometimes be difficult to find the initial point of trocar insertion. In the modern one-step technique, slightly higher pressure is required to insert the microcannula at an oblique angle, which may cause problems in eyes with recent corneal or scleral wounds [9]. Changing the insertion technique from one-step to two-step insertion or from vertical to angled insertion can improve sclerotomy leakage [4, 6]. These modifications of the insertion technique may not be sufficiently effective in myopic eyes with thin sclera and liquefied vitreous gel, or in fluid-filled eyes after vitrectomy with extensive removal of the peripheral vitreous [10, 11]. For these reasons, 25-G and 27-G instruments are considered to be advantageous in PPV for epiretinal membrane peeling and macular hole repair, but disadvantageous in retinal detachment surgery.

Rhegmatogenous retinal detachment (RRD) is the most common cause of retinal detachment and can lead to severe visual impairment if left untreated [12]. Risk factors include pseudophakia, myopia, trauma, and a family history of RRD [13, 14]. Surgical treatment consists of intraocular surgery with PPV and with pneumatic retinopexy (PR) or extraocular surgery with scleral buckling. PR and scleral buckling surgery are the methods of choice for uncomplicated, simple RRD, but they have been associated with several intraoperative and postoperative complications [15, 16]. Uncomplicated RRD is defined as RRD that is not associated with proliferative vitreoretinopathy (PVR) or as RRD with PVR Grade A or B [17]. Recently, improvements in instrumentation and increasing success rates of vitrectomy have increased the trend toward PPV in primary uncomplicated RRD [18, 19]. Postoperative silicone oil (SO) or gas tamponades have been used to support retinal attachment [20, 21]. SO is frequently preferred in complex RRD surgery, in cases where retinectomy is required or in patients who cannot maintain postoperative head position [22]. Gas tamponade use has become more popular in recent years as studies have shown lower visual outcomes with SO use [23–25]. Gas tamponade decreases the likelihood of postoperative hypotony [26], and studies have shown that fluid-filled eyes have a higher rate of postoperative hypotony compared to eyes filled with air or gas [27, 28].

Due to the surface tension effect of gas tamponades on sclerotomy wounds, we hypothesized that, in surgeries that benefit from 23-G instrumentation, single-stage sutureless sclerotomies using a gas tamponade would be effective in preventing postoperative hypotonia and other complications of wound leakage. We compared a single-stage vertical entry with two-stage tunnel entry in terms of postoperative IOP changes in patients using gas tamponade in 23-G PPV.

Materials and methods

Our study was a prospective, randomized, comparative interventional study in 103 eyes of 103 consecutive patients with primary, pseudophakic, uncomplicated RRD [17]. The study was approved

by the local ethics committee and adhered to the principles of the Helsinki declaration (Gaziantep University ethics committee 275). Informed consent was obtained from all patients. A true random number generator program (random.org) was used to randomly assign patients to either group. The program selected Group 1 for the first patient and so the next consecutive patient was assigned to Group 2. After this initial selection, each subsequent consecutive patient was assigned to alternating groups until the sample size was sufficiently large.

Inclusion criteria

Patients with relatively simple primary RRD with fresh superior retinal breaks were eligible for selection.

Exclusion criteria

Exclusion criteria were: patients with RRD and vitreous hemorrhage; where adequate fundus visualization was difficult; history of previous retinal or glaucoma surgery or previous retinal detachment; proliferative vitreoretinopathy (PVR); RRD with giant retinal tears; glaucoma; pathological myopia; and corneal surface abnormalities.

Examinations

Pre- and postoperative detailed ophthalmic history, best-corrected visual acuity (BCVA), slit-lamp examination, intraocular pressure (Goldmann tonometry), and detailed fundus examination findings via indirect ophthalmoscopy were recorded. Visual acuity was measured using Snellen eye test charts.

Surgical method

Operations were performed under local anesthesia (retrobulbar) by a single surgeon. A 23-G vitrectomy system (Dutch Ophthalmic Research Center, Zuidland, Holland) was used in all cases.

In the first group, a 23-G microvitreoretinal (MVR) blade trocar was placed at a 3.5-mm distance from the limbus (pars plana) using a special marker (DORC, Zuidland, Holland), at a 90° right angle to the transconjunctival sclera. No tunnel was created in the sclera.

In the second group, a tunnel was created with a 23-G MVR blade (45° angle; Yılmaz Medical–Ophthalmic Systems) at a 30° to 45° angle to the sclera (pars plana) at a 3.5-mm distance from the limbus. The trocar was then inserted into the scleral tunnel using a blunt inserter (DORC).

In both groups, trocars were placed in the inferotemporal, superotemporal and superonasal quadrants. A high-speed vitrectomy probe (2267.NMD06) surgical system (DORC Associate 2500 × 2, Zuidland, Netherlands) with a cutting speed of 2500–5000 per minute was used during PPV. The vitreous base was thoroughly cleaned via the vitrectomy probe and scleral indentation. Sulfur hexafluoride (SF6) gas at 20% concentration was used as a tamponade in all cases (GOT SF6 multi, Alchimia, Ponte S. Nicolo, Italy). At the end of the operation, the trocars were removed, and scleral massage was applied to the entry points and IOP control was performed with palpation. If necessary, additional gas mixture was injected through the pars plana to adjust the IOP. The sclerotomy sites were checked for air leakage. Postoperative antibiotics and corticosteroid eye drops were started in all patients, but subconjunctival injection was not performed.

Postoperative IOP and anterior segment biomicroscopic examination findings were recorded on the first day, first week and first month after the procedure. Additionally, BCVA and fundus findings were recorded at the first month. Hypotonia was defined as an IOP below 6 mmHg [29].

Statistical analysis

Descriptive statistics of the data obtained from the study are presented as mean and standard deviation for numerical variables and frequency and percentage for categorical variables. Comparison of demographic variables according to the type of vitrectomy operation was done using the Student t-test for numerical variables and Chi-square test for categorical variables. Statistical analysis was performed with SPSS, version 22.0 (IBM Inc., Armonk, NY, USA). Statistical significance was accepted as $p < 0.05$.

Results

In the first group, two eyes had an air leak although massage and sutures were placed at the sclerotomy sites. In the second group, air leak was observed in one eye and again sutures were placed at the sclerotomy opening. These three patients were excluded from the study. Thus, a total of 100 eyes in 100 patients were included in the study. The patient population consisted of 42 (42%) women and 58 (58%) men, with a mean age of 54.77 ± 11.96 years.

Group 1 included 50 patients: 22 females (44%) and 28 males (56%) with a mean age of 55.66 ± 13.43 years. Group 2 consisted of 50 patients (20 females (40%) and 30 males (60%)) with a mean age of 53.88 ± 10.36 years. There was no significant difference between the groups with regard to age and gender ($p = 0.460$ and $p = 0.685$, respectively). Surgery was performed using local anesthesia in all cases, and all patients were pseudophakic. No intraoperative complications were noted, and 20% SF6 was used in all cases. Initial reattachment was achieved in all cases, and no retinal detachment was present after one month postoperatively. The mean preoperative BCVA was 0.07 ± 0.12 and 0.08 ± 0.14 in Groups 1 and 2, respectively, while the mean postoperative BCVA was 0.32 ± 0.24 and 0.24 ± 0.21 in Groups 1 and 2, respectively. The mean preoperative IOP for Group 1 and Group 2 was 15.20 ± 2.93 and 14.78 ± 2.43, respectively. There was no statistical difference in preoperative IOP values ($p = 0.438$).

There was no statistically significant difference with regard to visual and postoperative IOP outcomes between the groups, and the data are summarized in Tables 1 and 2.

During the follow-up period, no serious complications such as endophthalmitis or retinal detachment (RD) were noted.

Discussion

The increase in the incidence of RRD observed in recent years may be partly related to the increase in the number of pseudophakic RRDs [30, 31]. Pseudophakic eyes have better access to the vitreous base compared to phakic eyes, resulting in a better completion of the recommended full shaving of the vitreous base [32]. Stangos et al. reported a reattachment rate of 97.78% after the first PPV in primary pseudophakic RRD [33]. Rapid developments in MIVS have increased vitrectomy success rates, making pars plana vitrectomy (PPV) with gas tamponade (SF6 or perfluoropropane (C3F8)) increasingly the preferred method in primary uncomplicated RRD [18, 19].

The severity and duration of postoperative hypotonia are influenced by three main intraoperative factors: the shape of the tunnel incision; the extent of removal of the vitreous base; and the choice of intraocular tamponade. The use of 25-G single-stage vertical entry PPV for diseases requiring peripheral vitrectomy has been associated with an increased incidence of postoperative hypotonia, endophthalmitis, and expulsive bleeding [34, 35]. Vitreous entrapment in the sclerotomy wound helps wound adhesion and decreases the incidence of postoperative hypotonia. Therefore, peripheral vitrectomy is not recommended in procedures with single-stage vertical entry [2, 3, 36]. Single-stage trocar insertion and sutureless sclerotomies are limited to smaller-gauge microincision vitrectomy surgery (25-G or 27-G) and cases that do not require peripheral vitrectomy, such as ERM peeling or macular hole repair. In cases where peripheral vitrectomy is mandatory as well as procedures using tamponades, such as liquid or silicone, different trocar insertion techniques have been described including angled (curved) incision, Zorros incision and Pollocks incision [37–39]. Oblique sclerotomies have been shown to close spontaneously and therefore cause

Table 1 Comparison of visual status and visual outcomes of patients who underwent vitrectomy

	Number of patients	Preoperative BCVA	Postoperative BCVA	*p*
Group 1	50	0.07 ± 0.12	0.32 ± 0.24	0.270
Group 2	50	0.08 ± 0.14	0.24 ± 0.21	

*t-Test

Table 2 Intraocular pressure measurements during follow-up

	n	Day 1	Week 1	Month 1	*p*
Group 1	50	15.06 ± 3.71	15.22 ± 2.71	15.78 ± 2.33	0.129
Group 2	50	16.14 ± 3.09	15.92 ± 2.59	16.14 ± 2.15	

*t-Test

fewer complications due to leakage compared to vertical incisions [37–40].

25-G instruments are more flexible than larger diameter instruments, a fact that makes it difficult to reach the peripheral regions of the retina and move the eye in the desired direction intraoperatively. The advantages of larger-diameter micro-incision vitrectomy surgery (23-G) are the rigidity of the instruments, making it easier to access anterior retinal pathology for treatments such as vitreous floor shaving, anterior laser, and anterior membrane peeling. This advantage may be indispensable, especially in retinal detachment operations. The ideal sclerotomy method would be a single-staged sutureless sclerotomy that could accommodate rigid, non-flexible, easy-to-manipulate vitrectomy instruments. Yamane et al. [41] showed that the wound closure rate was faster in 25-G sutureless vitrectomy in gas- or air-filled eyes compared to fluid-filled eyes and speculated that this difference was initiated by differences in surface tension. The re-adhesion force arising from the surface tension seemed to accelerate apposition of the wound. This force arises at the junction of the sclerotomy and pars plana gas–fluid interface. The surface tension leads to a decrease in the total gas–fluid interface, and the resulting force acts on the sclerotomy site encouraging wound closure. O'Reilly et al. [42] in PPV procedures using the 23-G sutureless sclerotomy reported hypotony in 25.6% of cases with spontaneous resolution and no complications, such as choroidal detachment or endophthalmitis, whereas Fine et al. [43] using the same system had a 2.5% rate of hypotony while using a gas tamponade in 52.9% of the cases. Schweitzer et al. [44] had a high incidence of postoperative hypotonia (22.8%), which they attributed to the low usage of gas tamponade; thus, these studies support the hypothesis that gas tamponades have a protective effect on postoperative hypotonia.

In the present study, we evaluated the postoperative IOP and possible complications of sclerotomies performed with two different techniques for 23-G vitrectomy in primary pseudophakic non-complicated RRDs. IOP below 6 mmHg was not present in either group. While IOP was 6 mm Hg in two patients in Group 1 and one patient in Group 2, these cases resolved spontaneously in the postoperative first week. The IOP was slightly higher in Group 2 on postoperative day 1, but this difference was not statistically significant (15.06 ± 3.71, 16.14 ± 3.09, respectively, $p = 0.129$). Postoperative BCVA increased in both groups, but no difference was observed between the postoperative BCVA increases in the two groups ($p = 0.270$). Single-stage vertical scleral entry did not increase the risk of postoperative infection. No endophthalmitis or other infection was observed in either group during the follow-up period. No retinal redetachment was observed in any of our patients during follow-up.

Eckard [4] reported that none of the eyes had IOP below 12 mmHg on the first postoperative day or at a later date during control examinations. In their study using air, gas, and balanced saline solution, Fuji et al. [2] reported a median IOP of 16 mmHg (range 10–21 mmHg) preoperatively and 12 mmHg (range 6–28 mmHg) on the first postoperative day. They reported median IOP as 16 mmHg at week 1 and month 1. Oshima et al. [5] reported mean IOP of 14.6 ± 3.0 mmHg preoperatively and 14.7 ± 5.1 mmHg, 14.5 ± 3.1 mmHg, and 13.8 ± 2.4 mmHg at postoperative day 1, week 1, and at the last visit, respectively. They reported that there was no difference in preoperative and postoperative IOP at any of the follow-up visits ($p = 0.203$). They also reported that the difference between eyes with long-acting gas or air tamponade and eyes without gas tamponade was not significant during the follow-up period ($p = 0.134$). In our study, in which we used 20% SF6 tamponade in all cases, the mean preoperative IOP for Group 1 was 15.20 ± 2.93. The mean IOP at the first day, first week, and first

month postoperatively was 15.06 ± 3.71, 15.22 ± 2.71, and 15.78 ± 2.33, respectively. The mean preoperative IOP for Group 2 was 14.78 ± 2.43. The mean IOP at the first day, first week, and first month postoperatively was 16.14 ± 3.09, 15.92 ± 2.59, and 16.14 ± 2.15, respectively.

This study has some limitations. Firstly, it describes only one surgeon's initial experiences with the 23-G vitrectomy system. Secondly, this study is based on postoperative IOP measurements alone, and future studies examining the outcomes with sclerotomy wounds with different methods, such as anterior segment optical coherence tomography, may make our hypothesis more reliable. Thirdly, the duration of surgery [45], which is thought to exert an effect on spontaneous closure of sclerotomy wounds, was not recorded. In addition, we believe that the surgical time was short in vitrectomy for well-chosen, relatively simple cases of RRD, which may have affected our results.

In conclusion, we observed that in 23-G sutureless vitrectomies performed using SF6 tamponade for uncomplicated RRD, single-stage vertical-entry sclerotomy and tunnel-entry sclerotomy had a similar postoperative IOP course and did not cause any complications during the follow-up period.

Funding The authors have no financial interests to report.

Declarations

Conflict of interest The authors have no conflict of interest to report.

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