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ORIGINAL PAPER

Comparative study of 27-gauge and 25-gauge vitrectomy performed as day surgery

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Abstract
Purpose To compare postoperative outcomes of 27-gauge (G) and 25-G vitrectomy conducted as day surgery.
Methods In total, 200 consecutive eyes that underwent primary vitrectomy (27-G in 100 eyes, 25-G in 100 eyes) were analyzed. 27-G vitrectomy was performed using a cut rate of 7500 cpm and 25-G vitrectomy using a cut rate of 5000 cpm.
Results The 27-G and 25-G groups did not differ significantly in underlying diseases and preoperative Early Treatment Diabetic Retinopathy Study (ETDRS) score. The time required for vitrectomy was significantly longer in the 27-G group (35.3 vs. 29.8 min, $P = 0.0013$). Postoperative hypotony was observed in 0 and 3 patients, and ocular hypertension in 10 and 14 patients in the 27-G and 25-G groups, respectively, showing more stabilized postoperative ocular pressure in the 27-G group. Gain in ETDRS score was significantly better in the 27-G group (12.1 ± 20.2 letters) compared to the 25-G group (10.0 ± 21.3 letters) ($P = 0.0323$) at 1 month postvitrectomy, but not significantly different at 3 and 6 months ($P = 0.0686$ and 0.0543). Rates of postoperative retinal detachment (1 vs. 1%) and vitreous hemorrhage (2 vs. 3%) were not different between two groups.
Conclusions 27-G vitrectomy requires longer operative time than 25-G, but using the 27-G system results in earlier visual improvement and stabilized ocular pressure.

Keywords Day surgery · Hypotony · Ocular hypertension · Operative time · Postoperative complications · 25-Gauge vitrectomy · 27-Gauge vitrectomy · Visual acuity

Introduction

Although 27-gauge (G) vitrectomy was initially conducted mainly for epiretinal membrane, idiopathic macular holes and vitreous hemorrhage [1, 2], indications for 27-G vitrectomy have since been expanded to include proliferative diabetic retinopathy, retinal detachment and proliferative vitreoretinopathy [3, 4].

Compared to 20-G vitrectomy, 23- or 25-G vitrectomy has various advantages including faster visual recovery [5–7], reduced postoperative intraocular inflammation [5, 8], lower incidence of corneal astigmatism [9, 10], stable intraocular pressure [7, 11], less patient discomfort [7] and shorter operative time

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[5, 7, 10]. Moreover, rates of postoperative complications were not different compared to 20-G vitrectomy [5, 7, 12].

Compared to 25-G vitrectomy, 27-G vitrectomy has been reported to require longer operative time, but there are no differences in postoperative visual acuity, postoperative inflammation and rate of hypotony [13].

Use of 27-G vitrectomy is expected to increase in the future. Therefore, understanding the characteristics of 27-G vitrectomy is necessary. In the present study, we compared 27-G with 25-G vitrectomy in patients with various indications, aiming to examine whether there are differences in visual outcome, postoperative complications, operative time and postoperative intraocular pressure.

Methods

This study was approved by the Ethical Committee of the Nihon University School of Medicine (Number 20161203). Informed consent was obtained from each subject following an explanation of the vitrectomy procedures and potential adverse effects of the procedure.

Inclusion and exclusion criteria

In this retrospective study, 200 eyes of 200 patients (83 females and 117 males) who underwent primary vitrectomy as day surgery between February 2014 and October 2015, and were followed for more than 6 months after vitrectomy were included in the analysis. Patients who required general anesthesia or systemic management and patients who desired inpatient treatment were excluded from the procedure. The mean patient age was 66.7 ± 10.4 (range 35–92) years. All surgeries were performed by two surgeons (H.S. and S.N.). There were no significant differences in operative time, surgical indications, surgical methods and surgical outcomes among the surgeries performed by the two surgeons.

Vitrectomy

Vitrectomy was conducted using a Constellation® system (Alcon Laboratories, Fort Worth, TX). Preoperative antisepsis was started on the day before surgery, by ocular instillation of topical levofloxacin (Shionogi, Osaka, Japan) six times a day. One hundred consecutive eyes underwent 25-G vitrectomy (Alcon Surgical) between February 2014 and December 2014, and 100 eyes underwent 27-G vitrectomy (Alcon Surgical) between January 2015 and October 2015.

Surgery was conducted under retrobulbar anesthesia in all patients. Flomoxef sodium (Shionogi, Osaka, Japan) was infused intravenously during surgery. After placing the lid speculum, the operative field was irrigated with 0.25% povidone–iodine [14]. The 0.25% povidone–iodine solution was freshly prepared before surgery, by diluting 10% povidone–iodine in sterile physiological saline. Using forceps, the conjunctiva was displaced slightly toward the cornea [15]. Incisions were made at an angle of 30 degrees to the sclera and parallel to the limbus, and three valved cannula trocar systems were inserted obliquely in a one-step procedure [16]. Twenty-five-gauge vitrectomy was performed using a cut rate of 5000 cuts per minute (cpm) and linear aspiration of 0–650 mmHg in all cases in this group. Twenty-seven-gauge vitrectomy was performed using a cut rate of 7500 cpm and linear aspiration of 0–650 mmHg in all cases in this group. Resight 700 (Carl Zeiss Meditec AG, Oberkochen, Germany) was used for posterior visualization. During vitrectomy, the operative field was flushed repeatedly with infusion fluid or 0.25% povidone–iodine.

Epiretinal membrane and macular hole were treated using 25-G or 27-G internal limiting membrane forceps (Alcon Laboratories) and plano-concave contact lens (Hoya, Tokyo, Japan). A chandelier light source was not used, and scleral buckling was not conducted in any case. Peripheral vitreous was excised using scleral indentation, until the cannula tip was exposed [17]. Even in patients with epiretinal membrane, 30% of the vitreous volume was replaced with air, and care was taken to ensure air tightness to facilitate early closure of the scleral wound. After removing each cannula, the sclerotomy roof was compressed with the tip of forceps on both sides to close the scleral wound. Air pressure was increased to 30 mmHg to close the sclerotomy floor. At the completion of surgery, if leakage of intraocular air occurred despite the above procedures, each of the three scleral wounds was closed with one stitch of absorbable suture through the conjunctiva. In some eyes, gas tamponade was performed using 17% sulfur hexafluoride (SF6) or 9% perfluoropropane (C3F8) in

air, and 1000 centistokes silicon oil (Alcon Laboratories) was used as endotamponade. Total operative time was defined as the time between placing of speculum and removal of speculum, excluding the time for cataract surgery. Total operative time included the port closure time in 10 cases. Vitrectomy time was defined as the time taken to perform vitrectomy only.

Simultaneous cataract surgery was conducted in patients 50 years of age or older because cataract tends to progress after vitrectomy. Cataract surgery was conducted using two types of viscoelastic materials; Viscoat (Alcon Laboratories) and Healon (AMO, Uppsala, Sweden). Phacoemulsification (Constellation; Alcon Laboratories) was performed through an incision in the superior cornea. A foldable intraocular lens (SN60WF; Alcon Laboratories) was inserted inside the capsule. Scleral and corneal wounds were closed with one nylon 10-0 suture, which was removed 1 week later. No pars plane lensectomy was performed in this series.

Pre- and postoperative examinations

Patients were examined before, and 1–2 days, 1 week, 2 weeks, 1 month, 3 and 6 months after surgery. Normal intraocular pressure (IOP) was defined as 10–21 mmHg. Hypotony was defined as an IOP of 6 mmHg or lower, and ocular hypertension as 25 mmHg or higher [3]. Corneal epithelial damage, anterior chamber inflammation, vitreous inflammation and the fundus were assessed at each postoperative follow-up using a slit lamp microscope and indirect ophthalmoscopy. Postoperative complications including hypotony, ocular hypertension, retinal detachment, endophthalmitis and choroidal detachment were also monitored.

Outcome measures

The outcome measures were intraoperative complications, wound closure at the end of surgery, operative time for vitrectomy, IOP on days 1 and 7, postoperative complications, and 1-, 3- and 6-month postoperative visual acuity. Visual acuity was measured using the Landolt ring chart, and the result was converted to Snellen visual acuity or Early Treatment Diabetic Retinopathy Study (ETDRS) score for analysis. Gain of ETDRS score after surgery was also analyzed.

Statistics

Statistical analyses were performed using SPSS software version 21 (SPSS, Inc., Chicago, IL). Data are expressed as mean ± standard deviation (SD) or percentage. Fisher's exact probability test, Chi-squared test for independent variable, or Mann–Whitney test was used to compare two groups. P values less than 0.05 were considered to be statistically significant.

Results

Baseline data

The 27-G and 25-G vitrectomy groups did not differ significantly in baseline characteristics (Table 1) including age (27-G vs. 25-G: 65.9 ± 10.2 vs. 67.5 ± 10.5; $P = 0.4133$), mean preoperative Snellen visual acuity (20/36 vs. 20/38; $P = 0.6922$) and ETDRS score (64.1 ± 23.6 vs. 62.5 ± 23.1; $P = 0.5065$), preoperative IOP (14.5 ± 3.3 vs. 14.6 ± 3.0 mmHg; $P = 0.8422$), preoperative spherical diopter power (−1.3 ± 3.1 vs. −1.3 ± 4.0 D; $P = 0.2913$). The proportion of eyes with epiretinal membrane, proliferative diabetic retinopathy, retinal vein occlusion and macular hole was 83% in the 27-G group and 90% in the 25-G group, with no significant difference between two groups ($P = 0.2144$).

Intraoperative and postoperative outcomes

The 27-G and 25-G groups did not differ significantly in percent of simultaneous cataract surgery (27-G vs. 25-G: 81 vs. 85%; $P = 0.5723$) and percent of air-filled eyes (83 vs. 89%; $P = 0.2639$) (Table 2).

Total operative time was significantly longer by approximately 5 min in the 27-G vitrectomy group (27-G: 44.7 ± 13.4 vs. 25-G: 39.2 ± 12.0 min, $P = 0.0015$). Vitrectomy time was also significantly longer by approximately 5 min in the 27-G vitrectomy group (35.3 ± 12.8 vs. 29.8 ± 11.7 min, $P = 0.0013$). No serious intraoperative complications occurred in either group. The incidence of postoperative complications including retinal detachment (1 vs. 1%) and vitreous hemorrhage (2 vs. 3%) was not significantly different between two groups ($P = 0.8091$), and all eyes recovered after undergoing

Table 1 Comparison of preoperative parameters between the 27-gauge and 25-gauge vitrectomy groups

Surgical system (number of eyes)	Mean age (years)	Preoperative ETDRS scores	Preoperative spherical diopter power (D)	Preoperative intraocular pressure (mmHg)	Disease (number of eyes)
27-Gauge vitrectomy (100)	65.9 ± 10.2 (35–87)	64.1 ± 23.6 (3–89)	−1.3 ± 3.1 (−15.0 to 4.0)	14.5 ± 3.3 (6–25)	Epiretinal membrane (51)
					Proliferative diabetic retinopathy (13)
					Retinal vein occlusion (10)
					Macular hole (9)
					Diabetic macular edema (3)
					Retinal detachment (3)
					Vitreous opacity and hemorrhage (10)
					Proliferative vitreoretinopathy (1)
25-Gauge vitrectomy (100)	67.5 ± 10.5 (41–92)	62.5 ± 23.1 (3–89)	−1.3 ± 4.0 (−16.5 to 7.5)	14.6 ± 3.0 (9–25)	Epiretinal membrane (56)
					Proliferative diabetic retinopathy (16)
					Retinal vein occlusion (13)
					Macular hole (5)
					Diabetic macular edema (4)
					Retinal detachment (3)
					Vitreous opacity and hemorrhage (3)
P value	0.4133*	0.5065*	0.2913*	0.8422*	

ETDRS Early Treatment Diabetic Retinopathy Study, *D* diopter power

* Mann–Whitney test

repeated vitrectomy. Snellen visual acuity was significantly better one month after vitrectomy in the 27-G group compared to the 25-G group ($P = 0.0323$), but not significantly different at 3 and 6 months after vitrectomy ($P = 0.0796$ and 0.1206, respectively). Gain of ETDRS score was significantly better one month after vitrectomy in the 27-G group (12.1 ± 20.2 letters) compared to the 25-G group (10.0 ± 21.3 letters) ($P = 0.0323$), but not significantly different at 3 and 6 months after vitrectomy ($P = 0.0686$ and 0.0543, respectively). No postoperative endophthalmitis, sclerotomy-related retinal tears and choroidal detachments were encountered during the follow-up period.

The rate of scleral wound suture was not significantly different between 27-G and 25-G vitrectomy (4 vs. 6%; $P = 0.7456$) (Table 3). Wound suture was required in 1 eye with retinal detachment and 3 eyes with silicon oil injection in the 27-G group, and in 3 eyes with retinal detachment and 3 eyes with silicon oil injection in the 25-G group. On postoperative day 1, IOP (16.9 ± 7.8 vs. 17.8 ± 8.0 mmHg) and rates of hypotony (0 vs. 3%) and ocular hypertension (10 vs. 14%) were apparently more favorable in the 27-G group, although there were no significant differences between two groups. On the 7th postoperative day, IOP (15.3 ± 4.5 vs. 15.3 ± 4.9 mmHg) as well as rates of hypotony (0 vs. 2%) and ocular hypertension

Table 2 Comparison of operative parameters and postoperative outcomes between the 27-gauge and 25-gauge vitrectomy groups

Surgical system (*n*)	Surgical procedure	Exchange procedure	Total operative time (min) Mean ± SD (range)	Vitrectomy time (min) Mean ± SD (range)	Postoperative complication	Postoperative ETDRS score gained		
						One month	Three months	Six months
27-Gauge vitrectomy (100)	PEA + IOL + VIT (81%) VIT (19%)	Air (83%) 17% SF_6 (6%) 9% C_3F_8 (8%) Silicon oil (3%)	44.7 ± 13.4 (23–92)	35.3 ± 12.8 (14–83)	RD (1%) VH (2%)	12.1 ± 20.2	15.1 ± 20.1	17.6 ± 21.7
25-Gauge vitrectomy (100)	PEA + IOL + VIT (85%) VIT (15%)	Air (89%) 17% SF_6 (2%) 9% C_3F_8 (6%) Silicon oil (3%)	39.2 ± 12.0 (19–77)	29.8 ± 11.7 (9–62)	RD (1%) VH (3%)	10.0 ± 21.3	14.3 ± 21.6	17.4 ± 21.5
P value	0.5723[a]	0.2639[a]	0.0015[b]	0.0013[b]	0.8091[a]	0.0323[b]	0.0686[b]	0.0543[b]

PEA phacoemulsification and aspiration, *IOL* intraocular lens implantation, *VIT* vitrectomy, *RD* retinal detachment, *VH* vitreous hemorrhage, *ETDRS* Early Treatment Diabetic Retinopathy Study

[a] Chi-squared test for independent variable

[b] Mann–Whitney test

Table 3 Wound suture, hypotony and ocular hypertension after 27-gauge and 25-gauge vitrectomy

Surgical procedure (*n*)	Wound suture at completion of surgery	First postoperative day			Seventh postoperative day		
		Mean ocular pressure (mmHg)	Hypotony	Ocular hypertension	Mean ocular pressure (mmHg)	Hypotony	Ocular hypertension
27-Gauge vitrectomy (100)	4/100 (4%)	16.9 ± 7.8 (7–53)	0/100 (0%)	10/100 (10%)	15.3 ± 4.5 (7–33)	0/100 (0%)	4/100 (4%)
25-Gauge vitrectomy (100)	6/100 (6%)	17.8 ± 8.0 (4–48)	3/100 (3%)	14/100 (14%)	15.3 ± 4.9 (6–30)	2/100 (2%)	4/100 (4%)
P	0.7456***	0.3008*	0.2462**	0.3831***	0.9551*	0.9551**	>0.9999***

Hypotony was defined as an IOP of 6 mmHg or lower. Ocular hypertension was defined as an IOP of 25 mmHg or higher

* Mann–Whitney test; ** Fisher's exact probability test; *** Chi-squared test for independent variable

(4 vs. 4%) improved compared to the 1st day in both 27-G and 25-G groups. IOP was stabilized in both 27-G and 25-G groups, with no significant difference between two groups.

Discussion

The present study showed that although the time for performing 27-G vitrectomy was approximately 5 min longer than that for 25-G vitrectomy, 27-G vitrectomy can be expected to result in early recovery of postoperative visual acuity. In this study, 1-month postoperative visual acuity was significantly better in the 27-G group than in the 25-G group. Various factors that potentially affect postoperative visual acuity following vitrectomy will be discussed, including the gauge of surgical instrument, operative time, postoperative inflammation, postoperative IOP, surgically induced astigmatism and postoperative complications.

Regarding the relationship between gauge of instrument and postoperative visual acuity, our study showed that gain in ETDRS score was significantly better one month after vitrectomy in the 27-G group compared to the 25-G groups ($P = 0.0323$), but not significantly different at 3 and 6 months after vitrectomy ($P = 0.0686$ and 0.0543, respectively). Sandali et al. [7] compared 20-G or 23-G with 25-G vitrectomy, and Kim et al. [11] compared 23-G with 25-G vitrectomy. Both studies reported earlier recovery of visual acuity when using 25-G vitrectomy. These results indicate that when comparing 27-G, 25-G, 23-G and 20-G vitrectomy, postoperative recovery of visual acuity is more rapid with smaller instrument gauge.

Vitrectomy time was 36.7 ± 12.8 min for 27-G and 32.7 ± 10.1 min for 25-G vitrectomy, with 27-G vitrectomy taking approximately 5 min longer ($P = 0.0323$). Mitsui et al. [6] reported operative time of approximately 31 min for 27-G and approximately 22 min for 25-G vitrectomy for epiretinal membrane. When comparing 27-G, 25-G, 23-G and 20-G vitrectomy, more time is required for vitreous excision as the instrument gauge decreases, resulting in longer operation time [5, 7].

One of the potential factors affecting recovery of visual acuity is postoperative inflammation. Inoue et al. [8] conducted an animal study to compare postoperative intraocular inflammation following 25-G, 23-G and 20-G vitrectomy, and reported that smaller gauge can minimize the inflammation associated with vitrectomy. In vitrectomy for epiretinal membrane, no difference in anterior chamber flare between 25-G and 27-G surgery has been reported [13]. Comparing 27-G, 25-G, 23-G and 20-G vitrectomy [7, 11], although the available data suggest that postoperative inflammation decreases when using smaller gauge cutter, further studies are required to clarify this point.

Postoperative hypotony is a common complication after microincision sutureless vitrectomy. When we compared 27-G with 25-G vitrectomy, the rate of wound suture was not different (27-G vs. 25-G: 4 vs. 6%). The rates of hypotony (0 vs. 3%) and ocular

hypertension (10 vs. 14%) observed on postoperative day 1 improved on day 7 in both groups, although the incidence of abnormal IOP changes on day 1 was apparently lower after 27-G vitrectomy. Although the difference in rate of hypotony between two groups was not statistically significant, it is clinically highly significant that no hypotony occurred in the 27-G group as compared to 3 cases in the 25-G group. Thus, 27-G vitrectomy has an important merit of reducing the risk of postoperative hypotony. A study comparing 25-G and 27-G vitrectomy for epiretinal membrane also found an apparently lower rate of hypotony for 27-G vitrectomy although the difference was not significant [13]. The results of comparisons among 23-G, 25-G and 27-G vitrectomy suggest that the rates of hypotony and ocular hypertension decrease with use of smaller gauge instruments, which may be associated with better wound closure in smaller gauge surgeries [7, 11].

Surgically induced astigmatism has been reported to be significantly less after 23-G and 25-G vitrectomy compared to 20-G vitrectomy [9, 10]. However, no difference in surgically induced astigmatism was observed between 25-G and 27-G vitrectomy in patients with epiretinal membrane [13]. These reports suggest that when 27-G, 25-G or 23-G vitrectomy is performed without suture, the risk of surgically induced astigmatism is low.

Postoperative complications of vitrectomy have been reported. In the present series, the rates of retinal detachment (1 vs. 1%) and vitreous hemorrhage (2 vs. 3%) did not differ between 27-G and 25-G vitrectomy, and all cases recovered by repeated vitrectomy. Several studies comparing 20-G, 23-G, 25-G and 27-G vitrectomy suggest that the risks of retinal breaks, retinal detachment and vitreous hemorrhage tend to be reduced when using smaller gauge instrumentation, but there are no significant differences [7, 12, 13].

The twin duty cycle vitreous cutter has been developed recently as a method to shorten operative time [18, 19]. The usefulness of 27-G twin duty cycle vitreous cutter has to be examined.

This study has some limitations. First, the study period of 27-G vitrectomy followed that of 25-G vitrectomy. We cannot exclude a possibility that the learning curve for surgical techniques such as sclerotomy creation and wound closure may have affected the postoperative visual outcome. Second, 27-G vitrectomy was performed using a cut rate of 7500 cpm and 25-G vitrectomy using a cut rate of 5000 cpm. The difference in cut rate may contribute to the difference in results. Third, we did not compare postoperative inflammation and surgically induced astigmatism in the present study, although Mitsui et al. [13] reported no significant differences of these two parameters between 25-G and 27-G vitrectomy. Fourth, although we found significantly better visual acuity in the early postoperative stage in the 27-G group compared to 25-G group, our retrospective study did not allow identification of the factors contributing to early recovery of visual acuity following 27-G vitrectomy. The extent of surgical invasion due to vitrectomy is known to differ depending on the disease treated. To address the limitations of this study, a prospective study on large numbers of patients treated for specific diseases which compares the detailed courses of visual outcome and inflammatory status between 27-G and smaller gauge instruments may elucidate the factors that improve visual outcome in 27-G vitrectomy.

In the present study that used angled scleral incision to perform 25-G and 27-G vitrectomy as day surgery, 27-G vitrectomy took 5 min longer to perform than 25-G surgery, but use of the 27-G system resulted in earlier visual improvement and stabilized ocular pressure after surgery.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical standard All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. This retrospective study was approved by the Ethical Committee of the Nihon University School of Medicine (Number 20161203).

Informed consent Informed consent for performing the procedures was obtained routinely from all the patients included in this study. For this retrospective study, formal consent of individual patients to be included in the study is not required.

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