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SURGICAL OUTCOMES OF 27-GAUGE VITRECTOMY FOR A CONSECUTIVE SERIES OF 163 EYES WITH VARIOUS VITREOUS DISEASES

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Purpose: To evaluate the safety and efficacy of 27-gauge vitrectomy for various vitreoretinal disorders.

Methods: In this retrospective comparative study, 163 consecutive eyes with various diseases that underwent 27-gauge pars plana vitrectomy with or without ultraspeed transformer by a single surgeon from June 2012 through December 2014 were analyzed in regard to best-corrected visual acuity, intraocular pressure, intraoperative and postoperative complications, and surgery time.

Results: In 2 eyes (1.2%), peripheral retina breaks were encountered intraoperatively, yet no other complications were found in those eyes. No cases required larger-gauge vitrectomy. Mean best-corrected visual acuity improved from 20/58 (logarithm of the minimum angle of resolution, 0.46 ± 0.64) preoperatively to 20/32 (logarithm of the minimum angle of resolution, 0.20 ± 0.40) postoperatively ($P < 0.001$). Mean follow-up was 16.7 months (range, 6–33 months). Intraocular pressure remained stable throughout the postoperative course. Hypotony was seen in 15 eyes (9.2%) at 1-day postoperative, yet that spontaneously improved within 1 week. No case of retinal detachment or endophthalmitis was recorded. In macular surgeries, such as idiopathic epiretinal membrane and macular hole combined with cataract surgery, the mean surgery time was 32.1 ± 6.9 minutes with ultraspeed transformer (n = 38) and 37.1 ± 7.7 minutes without ultraspeed transformer (n = 40) ($P = 0.004$).

Conclusion: The 27-gauge pars plana vitrectomy was found to be safe and effective for treating various vitreoretinal disorders.

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Small incisions are one of the latest innovative techniques currently used for most ophthalmologic surgeries. Sutureless vitrectomy in vitreoretinal surgery was initially proposed by Chen[1] in 1996. In 2002, Fujii et al[2,3] introduced the 25-gauge (G) vitrectomy system for sutureless self-sealing sclerotomy; however, the increased flexibility of the small 25-G instrument was one of the disadvantages associated with this technique. Eckardt[4] introduced sutureless 23-G vitrectomy in 2005, which offers a compromise between the 20-G and 25-G systems.

Sutureless posterior segment surgery provides numerous potential advantages over the traditional 20-G vitrectomy, including faster wound healing, diminished conjunctival scarring, improved patient comfort, decreased postoperative inflammation with early visual recovery, and reduced postoperative astigmatic change.[1,5–16] Moreover, the elimination of sutures also shortens the surgical opening and closing times.[17]

The introduction of transconjunctival microincision vitrectomy surgery with 25-G or 23-G instrumentation has resulted in low rates of intraoperative and postoperative complications, such as early postoperative hypotony and endophthalmitis.[2,4,13,18] In 2010, Oshima et al[19] described the initial feasibility and safety of a novel 27-G microincision vitrectomy surgery system and reported excellent visual and anatomical outcomes in a series of 31 patients. Recently, 27-G vitrectomy systems are available from various companies. This trend toward minimally invasive surgical intervention was one of the cases for phacoemulsification,[20–24] in which smaller sutureless incisions decreased ocular trauma and surgical time and resulted in decreased postoperative inflammation and faster patient recovery.

In this study, we examined 27-G vitrectomy in a consecutive series of cases to evaluate the safety, efficacy, and the functional outcome of a sutureless 27-G vitrectomy system performed by one surgeon using the same vitrectomy machine.

Methods

Study Design

This retrospective, consecutive, comparative, case series study included patients recruited from the Kyoto Prefectural University Hospital, Kyoto, Japan, and the Aiseikai Yamashina Hospital, Yamashina, Japan, who underwent vitrectomy by a single surgeon at a single site from June 2012 through December 2014, and approval for this study was obtained from the Ethics Committee of Kyoto Prefectural University of Medicine.

Patients

We retrospectively reviewed a consecutive series of 163 eyes of 145 patients who underwent 27-G vitrectomy for a variety of vitreoretinal disorders with a minimum of 6-month follow-up period.

Patients' medical records were reviewed, and the following parameters were collected and compared: age, preoperative and postoperative best-corrected visual acuity (BCVA), and intraocular pressure (IOP; at baseline and at 1-day, 1-week, and 1-month postoperative). Intraoperative and postoperative complications were also collected and reviewed. We could not know whether posterior vitreous detachment happened.

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Surgical Technique

The Accurus Surgical System (Alcon Lab Ltd) was used for all surgical procedures. All patients underwent a standardized 27-G vitrectomy combined with or without phacoemulsification and aspiration and intraocular lens implantation under retrobulbar anesthesia. We used miniquad (Volk Optical, Inc, Mentor, OH) and 27-G twin-light chandelier (DORC, Zuidland, Netherlands) in all cases. Of the 163 eyes, 81 eyes underwent 27-G vitrectomy using an ultraspeed transformer (UST) (DORC), and 82 eyes underwent vitrectomy without using the UST. In fact, UST boosts the cuts-per-minute (cpm) rate of the vitrectomy machines from 2,000 cpm up to 6,000 cpm. When we used UST, we used dedicated vitreous cutter (DORC) for UST. We got UST in the middle of this study period. We started using the UST in all 81 cases just after it was purchased.

In each operated eye, core vitrectomy and sclerotomy sites were made. Next, each eye received approximately 0.1 mL of intravitreal injection of triamcinolone acetonide suspension. In eyes with no preoperative posterior vitreous detachment, the posterior hyaloid membrane was detached at the optic disk by aspiration using a vitrectomy probe. In all eyes, the epiretinal membrane (ERM) and internal limiting membrane were removed, and the vitrectomies were performed by carefully making a 360° scleral depression to shave the anterior and posterior vitreous base. Fluid–air or fluid–gas exchange was used in some cases based on surgical indication. Endolaser photocoagulation was performed in eyes involving accidentally discovered or iatrogenic retinal tears.

In 27-G vitrectomy, the incisions were made by inserting a 27-G trocar, at a 30° to 40° angle through the conjunctiva, sclera, and pars plana 3.5 mm to 4 mm posterior to the limbus. The ERM was peeled from the surface of the retina and removed using 27-G internal limiting membrane forceps (DORC). Finally, after completion of the vitrectomy, microcannulas were removed from the scleral tunnels, and the conjunctiva was pushed laterally using a cotton wool applicator to separate it from the scleral incision. Pressure was then applied for a few seconds over the sclera to close the wound. At the end of surgery, all sclerotomy sites were inspected to detect bleb formation or any fluid leakage that may require suture placement. Typical intraoperative photographs of the 27-G vitrectomy system are shown in Figure 1.

Statistical Analysis

Visual acuity was recorded in Snellen visual acuity ratios and then converted to the logarithm of the

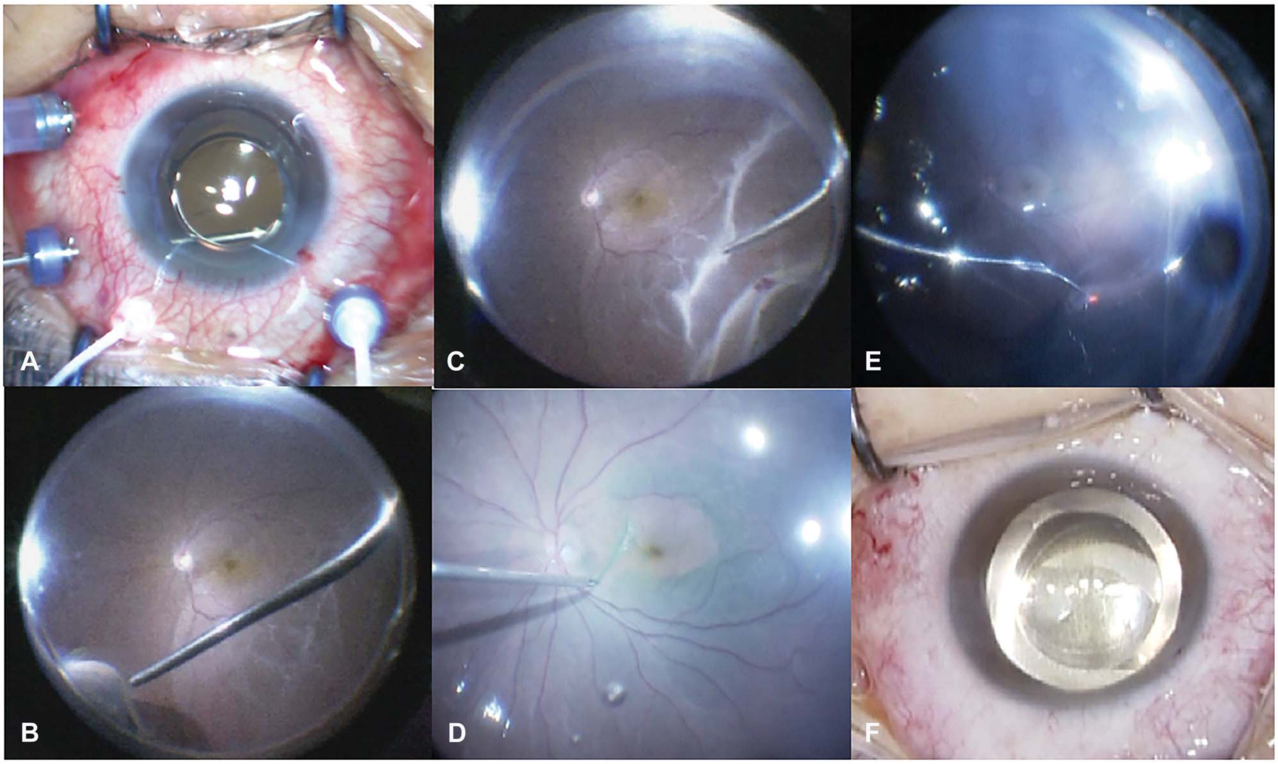

Fig. 1. Typical intraoperative photographs of the 27-G vitrectomy system. **A.** The setting of the 27-G vitrectomy system for treating rhegmatogenous retinal detachment. This case was performed with high-flow infusion (DORC) and Eckardt twin-light chandelier (DORC). One chandelier was fixed directly through the sclera, and the other was fixed to the trocar. **B.** Peripheral vitreous shaving was performed under the contact-type wide-angle viewing system and scleral indentation. **C.** Vitreous shaving on the detached retina was safely performed with the 27-G cutter and scleral indentation. **D.** Because this case had a macular hole, internal limiting membrane peeling was also performed. **E.** After the fluid–gas exchange was done, laser photocoagulation was performed with scleral indentation. **F.** Scleral suturing was not performed at the end of the 27-G vitrectomy. The conjunctiva remained stable with limited bleeding.

minimum angle of resolution (logMAR) equivalents for statistical analysis. Hypotony was defined as an IOP of <6 mmHg. All parameters were statistically analyzed using the paired *t*-test, with a *P* value of <0.05 considered to be statistically significant.

Results

In this study, 163 eyes of 145 patients (78 men and 67 women; mean age, 67.5 years) underwent 27-G pars plana vitrectomy and were observed for a mean period of 16.7 months (range, 6–33 months) postoperatively. Surgical indications of the 27-G vitrectomy were idiopathic ERM (74 eyes), macular hole (MH, 26 eyes), proliferative diabetic retinopathy (21 eyes), retinal vein occlusion (14 eyes), rhegmatogenous retinal detachment (12 eyes), and other (16 eyes; i.e., vitreous opacity [7 eyes], vitreomacular traction syndrome [5 eyes], and retinoschisis [4 eyes]) (Figure 2). Of the 163 eyes, 118 eyes underwent 27-G vitrectomy combined with phacoemulsification and aspiration and intraocular lens implantation, whereas 45 pseudophakic eyes underwent 27-G vitrectomy only. The overall mean BCVA improved from 20/58 (logMAR, 0.46 ± 0.64) before the surgery to 20/32 (logMAR, 0.20 ± 0.40) after the surgery ($P < 0.001$) (Figure 3). In 49 eyes, visual acuity improved more than 3 lines, remained unchanged within 3 lines in 108 eyes, and degenerated less than 3 lines in 6 eyes (Figure 4). The mean postoperative period before obtaining the BCVA was 2.40 ± 2.23 months (range, 1–12 months). The postoperative period for BCVA per month is shown in Figure 5. Eighty-six eyes obtained BCVA 1-month postoperatively. The overall results in each subgroup are summarized in Table 1. The overall mean preoperative IOP was 13.9 ± 3.8 mmHg (mean ± standard deviation: range, 5 mmHg–33 mmHg). The overall mean IOP at 1-day, 1-week, and 1-month postoperatively was 12.1 ± 6.0 mmHg (range, 1 mmHg–32 mmHg), 14.4 ± 4.5 mmHg (range, 6 mmHg–30 mmHg), and 15.4 ± 4.7 mmHg (range: 6 mmHg–40 mmHg), respectively (Figure 6). However, IOP was found to be significantly decreased at 1-day postoperatively ($P = 0.001$), not significantly changed at 1-week postoperatively, and significantly increased

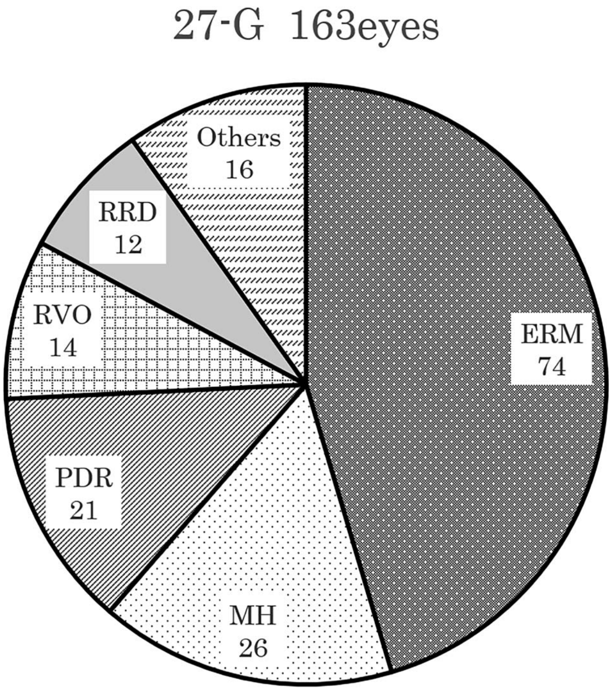

Fig. 2. Surgical indications of the 27-G vitrectomy. n, number of eyes; PDR, proliferative diabetic retinopathy; RRD, rhegmatogenous retinal detachment; RVO, retinal vein occlusion; others, vitreous opacities (7), vitreomacular traction syndrome (5), retinoschisis (4).

at 1-month postoperatively ($P = 0.002$). All operated eyes required peripheral vitreous shaving with scleral indentation and/or intraocular manipulation at the peripheral retina. No eyes required conversion to a larger-gauge instrument and no intraoperative complications related to the 27-G instrument, such as deformation of the microcannula, disconnection of the infusion cannula, or breakage of the vitreous cutter were observed. Their decisions were made by a surgeon and an assistant.

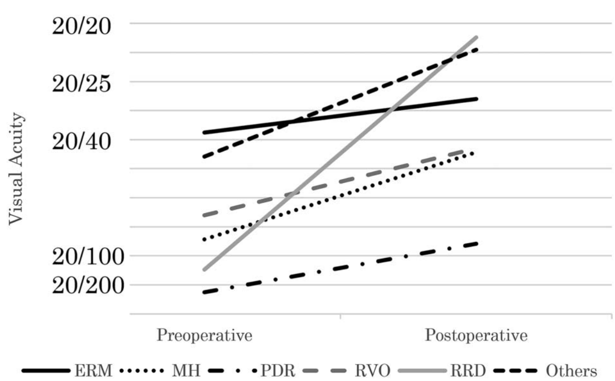

Fig. 3. Logarithm of the minimum angle of resolution (LogMAR) visual acuity by diagnosis. The mean postoperative BCVA was improved significantly in all subgroups except for RVO. n, number of eyes; PDR, proliferative diabetic retinopathy; RRD, rhegmatogenous retinal detachment; RVO, retinal vein occlusion.

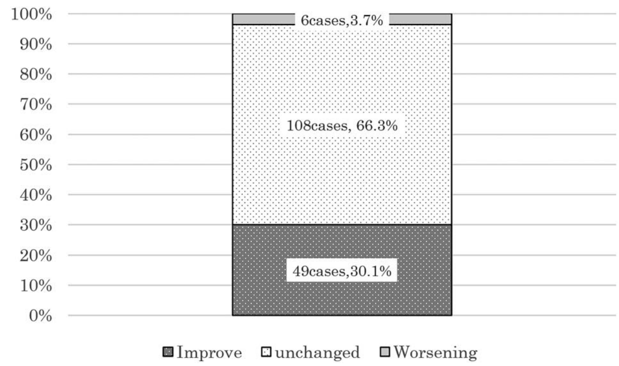

Fig. 4. Postoperative versus preoperative visual acuity observed at final time points in 163 cases of 27-G vitrectomy.

In 2 eyes (1.2%), one being MH and the other being proliferative diabetic retinopathy, peripheral retina breaks were encountered intraoperatively and simultaneously treated with laser photocoagulation, fluid–gas exchange, and gas injection. No other complications were found in these eyes throughout the follow-up visits. No eyes required a suture at the sclerotomy site because of leakage. Hypotony was observed in 15 eyes (9.2%) at 1-day postoperatively, and choroidal detachment was observed in 3 of those eyes. Transient hypotony in these eyes spontaneously improved within 1 week. Mild vitreous hemorrhage occurred in 3 eyes, and there were no cases of endophthalmitis (Table 2).

In all 76 eyes that underwent vitrectomy for an idiopathic ERM, the membrane was successfully removed without intraoperative complications, and no recurrence of membrane proliferation was observed during the study period. The mean preoperative visual acuity was 20/32 (logMAR, 0.20 ± 0.29). The mean postoperative BCVA was 20/27 (logMAR, 0.13 ± 0.13), and the difference from preoperative value was statistically significant ($P = 0.012$). The mean surgery time was 31.8 ± 7.9 minutes.

In all 26 eyes that underwent vitrectomy for an idiopathic MH, successful closure of the hole was achieved via the initial surgery with the use of 20%

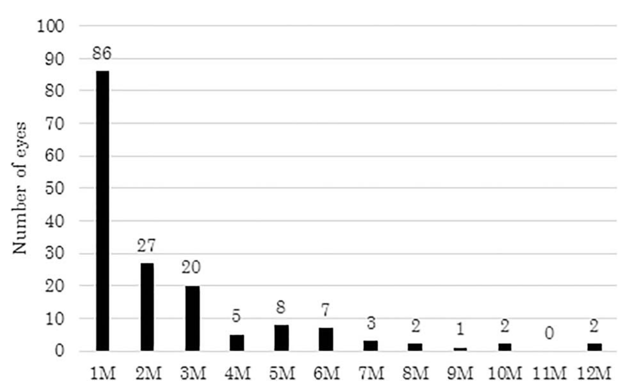

Fig. 5. Duration until achieving postoperative BCVA. M, Month(s).

Table 1. Overall Patient Profile and Surgical Outcomes

Diagnosis (n)	Phacovitrectomy/ Only Vitrectomy	Mean Age, ±SD, Year	Mean Pr., LogMAR ± SD	Mean Po., LogMAR ± SD	Improvement in Visual Acuity, P	Mean Pre. IOP, ±SD
Total (163)	118/45	67.5 ± 8.6	20/58 (0.46 ± 0.64)	20/32 (0.20 ± 0.40)	0.001	13.9 ± 3.8
ERM (74)	55/19	68.3 ± 7.5	20/32 (0.20 ± 0.29)	20/27 (0.13 ± 0.30)	0.01	14.0 ± 3.4
MH (26)	23/3	66.8 ± 7.1	20/78 (0.59 ± 0.36)	20/36 (0.25 ± 0.29)	0.001	14.0 ± 2.7
PDR (21)	11/10	64.0 ± 11.2	20/270 (1.13 ± 1.10)	20/83 (0.62 ± 0.74)	0.02	15.5 ± 5.6
RVO (14)	11/3	74.1 ± 6.1	20/59 (0.47 ± 0.48)	20/35 (0.24 ± 0.23)	0.13	13.4 ± 3.2
RRD (12)	10/2	61.3 ± 8.6	20/132 (0.82 ± 0.90)	20/21 (0.03 ± 0.20)	0.01	12.2 ± 4.9
Others (16)	8/8	68.2 ± 8.2	20/37 (0.27 ± 0.37)	20/22 (0.04 ± 0.14)	0.04	12.9 ± 2.6

Diagnosis (n)	Mean Po. Day 1 IOP, ±SD	Mean Po. Week 1 IOP, ±SD	Mean Po. Month 1 IOP, ±SD	Mean Operating Time, Minutes	Mean Follow-Up, ±SD, Months	UST/Non UST	Phaco Vitrectomy UST/Non UST
Total (163)	12.1 ± 6.0	14.4 ± 4.5	15.4 ± 4.7	34.8 ± 13.2	16.7 ± 8.6	81/82	62/56
ERM (74)	11.7 ± 5.6	14.3 ± 4.3	15.2 ± 5.0	31.8 ± 7.9	19.4 ± 8.0	30/44	25/30
MH (26)	13.7 ± 4.1	14.3 ± 4.2	15.3 ± 3.4	34.6 ± 9.4	15.3 ± 9.0	14/12	13/10
PDR (21)	14.0 ± 7.3	14.3 ± 4.7	17.0 ± 6.2	44.5 ± 21.0	15.4 ± 9.1	11/10	5/6
RVO (14)	12.1 ± 7.5	14.6 ± 3.9	15.7 ± 3.9	35.0 ± 13.0	13.6 ± 6.3	8/6	7/4
RRD (12)	9.9 ± 7.9	16.2 ± 6.3	15.8 ± 4.1	48.3 ± 14.1	17.4 ± 7.6	5/7	5/5
Others (16)	10.2 ± 3.4	13.2 ± 3.7	13.3 ± 3.2	26.2 ± 10.0	10.7 ± 6.9	13/3	7/1

n, number of eyes; PDR, proliferative diabetic retinopathy; po., postoperative; pr., preoperative; RRD, rhegmatogenous retinal detachment; RVO, retinal vein occlusion; SD, standard deviation.

sulfur hexafluoride as a long-acting tamponade. The mean visual acuity was 20/78 (logMAR, 0.59 ± 0.36), yet it significantly improved to 20/36 (logMAR, 0.25 ± 0.29) at the final visit ($P < 0.0001$). The mean surgery time was 34.6 ± 9.4 minutes.

Of the 21 eyes that underwent surgery for proliferative diabetic retinopathy, the reason for undergoing vitrectomy was vitreous hemorrhage in 11 eyes and tractional retinal detachment in 10 eyes. Gas tamponade was performed in 3 of the 21 eyes (14%) (i.e., 2 eyes with sterile air and 1 eye with sulfur hexafluoride). The mean preoperative visual acuity was 20/270 (logMAR, 1.13 ± 1.10), yet it significantly improved to a mean postoperative BCVA of 20/83 (logMAR, 0.62 ± 0.74) ($P = 0.02$). The mean surgery time was 44.5 ± 20.9 minutes.

Of the 14 eyes that underwent surgery for retinal vein occlusion, 13 eyes had branch retinal vein occlusion and 1 eye had central retinal vein occlusion. All 14 eyes had persistent macular edema, and 6 eyes also had vitreous hemorrhage. The mean preoperative visual acuity was 20/59 (logMAR, 0.47 ± 0.48), and the mean postoperative BCVA was 20/35 (logMAR, 0.24 ± 0.23) with no significant improvement ($P = 0.13$). The mean surgery time was 35.0 ± 13.0 minutes.

In all 12 eyes with rhegmatogenous retinal detachment, retinal attachment was successfully achieved by the initial surgery, and peripheral vitreous shaving was performed. Gas tamponade was performed in 11 of the 12 eyes (92%): 8 eyes with 20% sulfur hexafluoride and 3 eyes with sterile air. No postoperative complications were observed in all 12 eyes in this subgroup throughout the follow-up period. The mean preoperative visual acuity was 20/132 (logMAR, 0.82 ± 0.90), and it significantly improved to a mean BCVA of 20/21 (logMAR, 0.03 ± 0.20) after the surgery ($P = 0.01$). The mean surgery time was 48.3 ± 14.1 minutes.

Because vitrectomy was performed stereotypically in the cases of macular diseases, such as ERM or MH, the surgery times of the macular surgeries of ERM and

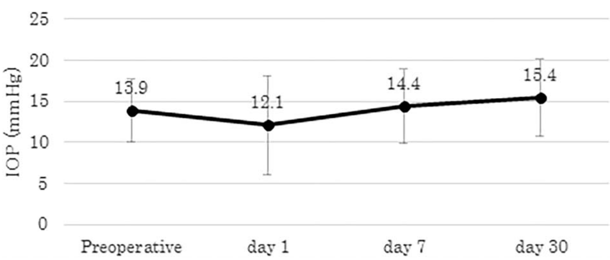

Fig. 6. Changes in mean IOP in 27-G vitrectomy. Intraocular pressure was found to be significantly decreased at 1-day postoperative ($P = 0.001$), not significantly changed at 1-week postoperative, and significantly increased at 1-month postoperative ($P = 0.002$).

Table 2. Intra- and Postoperative Complications in 27-Gauge Vitrectomy

	Eyes (%)
Intraoperative complications	
Inadvertent retinal breaks	2/163 (1.2)
Preoperative complications	
Transient hypotony (IOP < 6 mmHg)	15/163 (9.2)
Choroidal detachment as a result of hypotony	3/163 (1.8)

Table 3. The Efficiency of Ultra Speed Transformer

The Efficiency of UST	Operating Time, Minute	P
Surgery with UST (n = 38)	32.1 ± 6.9	0.004
Surgery without UST (n = 40)	37.1 ± 7.7	

MH were compared to evaluate the efficiency of UST (Table 3 and Figure 6; i.e., the surgery times of the patients who underwent pars plana vitrectomy combined with cataract surgery). The mean surgery time was 32.1 ± 6.9 minutes with UST (n = 38 eyes) and 37.1 ± 7.7 minutes without UST (n = 40 eyes) (P = 0.004). Hence, the surgery time was significantly shortened via the use of UST.

We also compared the surgery time needed for the nonmacular diseases with cataract surgery. The mean surgery time was 34.8 ± 13.4 minutes with UST (n = 24 eyes) and 51.6 minutes without UST (n = 16 eyes) (P = 0.002). However, it should be noted that there were many variations of surgical indications. Moreover, for the treatment of nonmacular diseases, a low proportion of the total surgery time is spent on core vitrectomy and peripheral shaving because laser photocoagulation and treating proliferative membrane are needed in those eyes. Thus, it was difficult to determine the efficacy of UST in those cases.

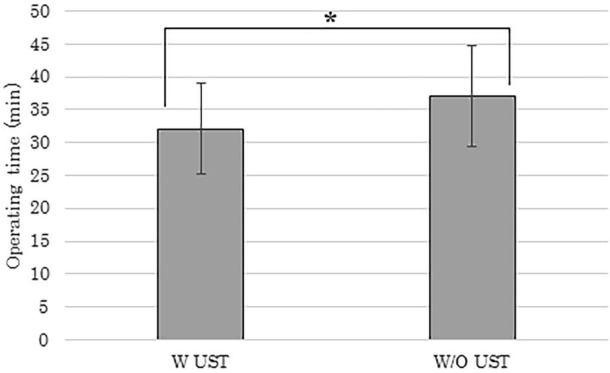

Fig. 7. Comparison of the surgery time with UST or without UST in macular surgeries. The surgery time was 32.1 ± 6.9 minutes with UST (n = 40) and 37.1 ± 7.7 minutes without UST (n = 38) (*P = 0.004). The surgery time was significantly shortened via the use of UST. W, with; W/O, without.

Discussion

There are both advantages and disadvantages associated with using the 27-G vitrectomy system. Compared with other vitrectomy systems, which use a different incision size, such as the 25-G or 23-G systems, the 27-G system induces minimal ocular trauma, may decrease the inflammatory response, and may allow for overall faster patient recovery. In comparison with the different incision size associated with the 25-G and 23-G vitrectomy systems, the findings of this study indicate that the 27-G vitrectomy system produces similar outcomes when performed on a variety of diseases. However, there are some disadvantages associated with the smaller-gauge vitrectomy system, including the weakness of the instruments and the fact that the procedure is less efficient.

Minimally invasive vitreoretinal surgery has been proposed in the past by other authors.[5–8,10,25] Chen[1] proposed a sutureless tunnel-based sclerotomy, but the case series reported in that study revealed difficulty in the passage of conventional instruments along with several complications, including wound extension, dehiscence, and leakage, vitreous and/or retinal incarceration, hemorrhage, retinal tears, and dialysis.[1,5,8] As a result of the weakness and reduced efficiency of the 27-G instruments, some studies have reported the necessity of converting to a larger-gauge system. However, none of the cases in the present study required conversion to larger-gauge devices, instruments, or infusion.

Postoperative hypotony reportedly ranges between 0% and 25% in cases undergoing sutureless vitrectomy.[26,27] In our study, hypotony was observed in 15 eyes (9.2%) at 1-day postoperatively, and choroidal detachment was observed in 3 of those eyes. However, the transient hypotony in those eyes spontaneously improved within 1 week after the surgery. Oshima et al[19] reported that the overall mean IOP before and after the surgery when using the 27-G system was stable with no significant differences among the examined time points (i.e., 1, 7, and 30 days postoperatively). However, they used long-acting gas or air tamponade in some cases, and the mean IOP at 1-day postoperatively in eyes without gas tamponade was lower than that in eyes with it. In addition, Yamane et al[28] found that in patients undergoing 25-G pars plana vitrectomy, IOP at 1-day postoperatively was significantly higher in gas-filled eyes than in fluid-filled eyes.

Vitrectomy for typical macular diseases was performed stereotypically. However, in cases involving other diseases such as vitreous hemorrhage (as a result of various reasons), rhegmatogenous retinal detachment, or proliferative diabetic retinopathy, the surgery time depended on the specific procedures with the exception of the core and peripheral vitrectomy. Therefore, we compared the surgery time of the macular surgeries, such as those for ERM and MH, in regard to the efficiency of the 27-G vitrectomy system (Figure 7). We found that the surgery time was significantly shortened when using the UST, as it boosts the cpm rate of the vitrectomy machines from 2,000 cpm up to 6,000 cpm. Our results indicate that use of the UST is more effective and time saving for a smaller-gauge vitrectomy, such as the 27-G system. We hypothesized that the difference in efficiency of UST between the 25-G and 27-G systems is caused by both the difference of the duty cycle and the fluid resistance of the narrow lumen. With a higher cut rate, both the duty cycle and the fluid resistance are reduced. In regard to the efficiency of 25-G vitrectomy, our results suggest that the fluid resistance is not so great for thicker lumen and that the duty cycle produces the difference. Conversely, in the smaller-gauge 27-G system, the fluid resistance greatly influences the surgical efficiency, although the effect of the duty cycle is insignificant. Altogether, the 27-G vitrectomy for macular surgical procedures is sufficiently safe and effective compared with 25-G vitrectomy, and the smaller incision is thought to produce less tissue invasion.[29]

It was previously reported that 25-G vitrectomy contributes to earlier visual recovery compared with 20-G vitrectomy,[18,30,31] whereas that of the 27-G and 25-G vitrectomy systems is similar.[32] Thus, the advantages of 27-G vitrectomy are likely similar to those of 25-G vitrectomy in terms of postoperative visual recovery. Moreover, it was also reported that aqueous flare values and cell counts recovered to the baseline levels earlier following 27-G vitrectomy than after 25-G vitrectomy.[32] Thus, 27-G vitrectomy may cause less surgical trauma to the eye than 25-G vitrectomy.

It should be noted that one limitation of this study is its retrospective design. However, and to the best of our knowledge, this is the first and largest study to evaluate the safety and visual outcome of 27-G vitrectomy in various types of diseases.

In conclusion, the findings of this study demonstrate that for the treatment of a variety of ocular diseases, the 27-G vitrectomy system is as safe and effective as larger-gauge vitrectomy systems, significantly reduces the surgery time when using the UST, and offers earlier postoperative visual recovery.

Key words: 27-gauge, retina, surgical outcome, vitrectomy.

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