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RETINAL DISORDERS

Intraoperative iatrogenic peripheral retinal break in 23-gauge transconjunctival sutureless vitrectomy versus 20-gauge conventional vitrectomy

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Abstract
Background To compare the incidence of intraoperative iatrogenic peripheral retinal breaks (IPRBs) during 23-gauge transconjunctival sutureless vitrectomy (TSV) and conventional 20-gauge vitrectomy for various indications.
Methods This was a single-center, comparative, retrospective, interventional case series of 973 23-gauge TSVs and 402 conventional 20-gauge vitrectomies done by two surgeons between January 2004 and December 2009. The incidence rate of intraoperative IPRBs and risk factors were analyzed in association with various clinical and surgical factors.
Results IPRBs occurred significantly less often during 23-gauge TSV (16 of 973 cases, 1.6 %) than during conventional vitrectomy (25 of 402 cases, 6.2 %, $P<0.001$). Univariate analysis revealed that conventional vitrectomy and operation time were risk factors for the complication. Multivariate logistic regression analysis also revealed that conventional vitrectomy ($P=0.03$, OR=2.91), operation time ($P<0.01$, OR=1.01), and intraoperative induction of posterior vitreous detachment (PVD, $P=0.04$, OR=1.97) were risk factors for IPRBs.
Conclusions The 23-gauge TSV procedure with the trocar system has a lower incidence of intraoperative IPRBs than conventional 20-gauge vitrectomy. Longer operation time and induction of PVD are also independent risk factors of the complication.

Keywords 20-gauge · 23-gauge · Intraoperative iatrogenic peripheral retinal break · Sclerotomy-related retinal break · Transconjunctival sutureless vitrectomy · Vitrectomy

Introduction

The advent of smaller than 20-gauge vitrectomy system is thought of as a significant advance in the history of pars plana vitrectomy. The 25-gauge transconjunctival sutureless vitrectomy (TSV) system was introduced by Fujii et al. [1] and the 23-gauge TSV was introduced by Eckardt [2]. The use of small incision TSV systems has been broadening because of various advantages over conventional 20-gauge system (e.g., shorter operation and healing times, decreased postoperative discomfort) [3].

Despite this, which vitrectomy system has a better safety profile has not been shown. The self-sealing of operative wounds with small-gauge TSV may theoretically increase the risk of postoperative hypotony and endophthalmitis [4, 5]. The incidence rate of iatrogenic peripheral retinal break (IPRB), a serious complication that may lead to retinal detachment, ranged from 0 % to 24.3 % in previous studies [6–16]. There have been several reports that compared the incidence of IPRB between 20-gauge conventional

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vitrectomy and small-gauge TSV, which showed that the incidence of IPRB might be lower with TSV [17–19]. However, these studies had limitations in that only specific vitreoretinal diseases, such as macular disease and proliferative diabetic retinopathy, were analyzed.

This study was designed to compare the incidence rate of intraoperative IPRB that occurs with 23-gauge cannulated TSV compared to conventional 20-gauge uncannulated vitrectomy. Various vitreoretinal diseases were studied and risk factors associated with intraoperative IPRBs were examined.

Material and methods

Patients and data collection

This was a single-center, comparative, retrospective interventional case series. The electronic medical records from all patients who underwent 20-gauge vitrectomy, from January 2004 to December 2007, and 23-gauge TSV, from June 2006 to December 2009, were reviewed. Surgeries were performed by two surgeons (KHP, WSJ) at a single hospital.

An iatrogenic peripheral retinal break (IPRB) was defined as a definite retinal break that is located from the mid-periphery to the vitreous base and not found on thorough preoperative fundus examination. Patients who underwent vitrectomy due to rhegmatogenous retinal detachment or complications from trauma were excluded from the study. Eyes that had undergone a previous vitrectomy, or that had a vitreous hemorrhage associated with peripheral retinal tear, were also excluded. Finally, 973 cases of 23-gauge TSV and 402 cases of 20-gauge conventional vitrectomy were consecutively examined and analyzed in this study. Patients provided informed consent prior to surgery, and the study protocol was approved by the Institutional Review Board of Seoul National University Bundang Hospital.

Thorough ophthalmic examinations were performed before surgery. Such examinations helped detect any peripheral retinal breaks. Preoperative data included patient age, gender, laterality, lens state, and indication for vitrectomy. Intraoperative data included surgeon, operation time length, if vitrectomy was combined with a cataract operation, if intraoperative posterior vitreous detachment (PVD) developed, and if IPRBs occurred.

Surgical methods

All 23-gauge TSVs were performed using the method and instruments suggested by Eckardt [2], as fully described in our previous report [20, 21]. A sclerotomy was made using a two-step maneuver with a 23-gauge stiletto blade (45° angle; BD Medical–Ophthalmic Systems, Franklin Lakes, NJ), and a blunt inserter combined with a microcannula (DORC, Zuidland, Holland). Oblique scleral tunnel wounds were constructed at an angle less than 15° to the sclera. Twenty three-gauge instruments were inserted through the microcannulas during the vitrectomy, and a pneumatic vitreous cutter was used in conjunction with the vitrectomy unit (Accurus, Alcon Surgical, TX). In cases that required internal tamponade, gas (18 % SF_6) or silicone oil (Arciolane 1300 CS, Arcadophta Inc., Toulouse, France) was injected intravitreally.

A conventional 20-gauge vitrectomy was performed using the standard three port pars plana approach, with the conjunctival incisions exposing the temporal and nasal sclera. Cannulas were not used, and all sclerotomies were sutured with 8-0 vicryl. The same vitrectomy system (Accurus, Alcon Surgical Inc., TX) was also used in 20-gauge vitrectomies, although the size of vitreous cutter and endoilluminator was larger.

We used a conventional contact lens system for macular surgeries and non-contact wide field lens system (Binocular Indirect Ophthalmo Microscope, Oculus Inc., Germany) for the other indications of the vitrectomy. Depression of sclera was always needed for peripheral vitrectomy at the end of the surgeries, using a Schocket-style double-ended scleral depressor (E5108, Karl Storz, Tuttlingen, Germany). When an IPRB was detected, endolaser or cryotherapy was applied to prevent secondary retinal detachment. In one case of retinal dialysis, a scleral buckle was also performed.

Statistical analysis

Demographic data, surgical data, surgical indication, and IPRB occurrence were compared between 23-gauge TSV and conventional vitrectomy groups using chi-square and independent t-tests. Univariate analyses were also performed to reveal risk factors for IPRBs using Pearson's chi-square test and binary logistic regression analysis. Multivariate analysis, using multiple binary logistic regression analysis, was done to adjust for various confounding factors. *P* values of <0.05 were considered statistically significant. Statistical analyses were performed using SPSS for Windows (Ver. 18.0, Statistical Package for the Social Sciences, SPSS Inc., Chicago, IL).

Results

The clinical and surgical characteristics of patients, along with the indication for vitrectomy, are listed in Table 1. There were 973 cases in which the procedure was performed with the 23-gauge TSV system and 402 cases in which the procedure was performed with the conventional 20-gauge system. Gender and ocular dominance ratios were statistically similar between the groups. However, age, surgeon, lens state, rate of combined cataract operation, induction of

Table 1 Clinical characteristics and surgical parameters by group for all vitrectomy cases

Parameters	23-gauge vitrectomy	20-gauge vitrectomy
Number of cases (eyes)	973	402
Age at operation (years)	60.6±12.5	58.7±12.6
Gender (M:F)	434:539	185:217
Ocular dominance (R:L)	506:467	205:197
Surgeon (PKH:WSJ)	535:438	401:1
Phakia/Pseudophakia or aphakia	777:196	338:64
Combined cataract operation	505 (51.9 %)	119 (29.6 %)
Intraoperative PVD induction	315 (32.4 %)	89 (22.1 %)
Operation time (minutes)	62.9±27.3	111.3±36.8
Indication for surgery		
Vitreous hemorrhage/opacity	316 (32.5 %)	128 (31.8 %)
Epiretinal membrane	259 (26.6 %)	49 (12.2 %)
Macular hole	142 (14.6 %)	55 (13.7 %)
Traction retinal detachment	124 (12.7 %)	92 (22.9 %)
Retained lens	29 (3.0 %)	21 (5.2 %)
IOL dislocation	14 (1.4 %)	7 (1.7 %)
Vitreomacular traction	21 (2.2 %)	2 (0.5 %)
Macular edema	31 (3.2 %)	11 (2.7 %)
Endophthalmitis	15 (1.5 %)	9 (2.2 %)
Retinal Vein Occlusion	5 (0.5 %)	11 (2.7 %)
Subretinal hemorrhage	7 (0.7 %)	12 (3.0 %)
Others[a]	10 (1.0 %)	5 (1.2 %)
Iatrogenic peripheral retinal break (IPRB)	16 (1.6 %)	25 (6.2 %)
SRRB	7 (0.7 %)	11 (2.7 %)
IPRB (other than SRRB)	9 (0.9 %)	14 (3.5 %)

[a] Others: phacolytic glaucoma, retinal capillary hemangioma, persistent hyperplastic primary vitreous

PVD posterior vitreous detachment; *SRRB* sclerotomy-related retinal break (IPRB located within 1 o/c of sclerotomy sites); IOL intraocular lens

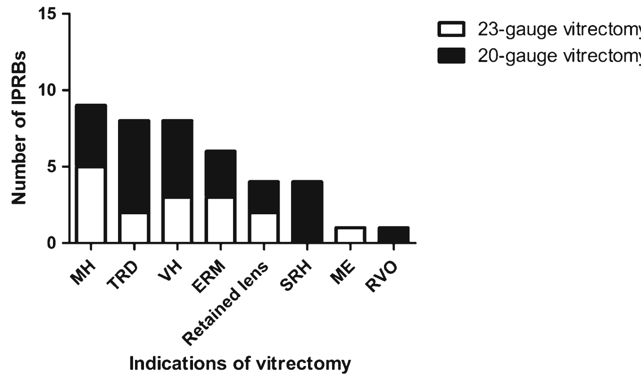

Fig. 1 Incidence of iatrogenic peripheral retinal breaks (IPRBs) by various surgical indications. The IPRBs were observed in nine eyes of MH patients (N=197, 4.6 %), eight eyes of TRD patients (N=216, 3.7 %), eight eyes of VH patients (N=444, 1.8 %), six eyes of ERM patients (N=308, 1.9 %), four eyes of retained lens patients (N=50, 8.0 %), four eyes of SRH patients (N=19, 21.1 %), one eye of ME patients (N=42, 2.4 %), and one eye of RVO patients (N=16, 6.3 %). *MH* macular hole; *TRD* tractional retinal detachment; *VH* vitreous hemorrhage; *ERM* epiretinal membrane; *SRH* subretinal hemorrhage; *ME* macular edema; *RVO* retinal vein occlusion

intraoperative PVD, indication for surgery, and operation time were significantly different between the groups. The incidence rate of IPRBs was 3.0 % (41 of 1,375 cases) for all patients. The complication occurred in 1.6 % (16 of 973) of TSV cases and in 6.2 % (25 of 402) of conventional vitrectomy cases, a difference that was statistically significant (P<0.001).

The mean age of patients who had IPRBs was 57.5±13.9 years, which was not statistically different from patients who did not (60.1±12.5 years, P=0.18). The mean operation time of the IPRB group was 107±48 min, which was statistically higher than the non-IPRB group (76±37 min, P<0.001). The indications of vitrectomy in which IPRBs were observed were as follows (Fig. 1): nine cases in macular hole (N=197, 4.6 %), eight cases in tractional retinal detachment (N=216, 3.7 %), eight cases in vitreous hemorrhage (N=444, 1.8 %), six cases in epiretinal membrane (N=308, 1.9 %), four cases in retained lens (N=50, 8.0 %), four cases in subretinal hemorrhage (N=19, 21.1 %), one case in macular edema (N=42, 2.4 %), and one case in retinal vein occlusion (N=16, 6.3 %). No occurrences of IPRB were observed in cases of intraocular lens (IOL) dislocation, vitreomacular traction, or endophthalmitis. Endolaser (23 cases), cryotherapy (17 cases) and scleral buckling (1 case) were used to treat IPRB sites to prevent progression to retinal detachment, a potentially devastating complication.

Cases with IPRB were striated into two groups; those IPRBs located within one clock hour of sclerotomy sites (sclerotomy related retinal break [SRRB] group) and those that were not (non-SRRB group). Eighteen of 41 cases (44 %) were SRRBs, and the remaining 23 cases (56 %) were non-SRRBs. The location of SRRBs were as follows: ten cases within 10 o'clock (o/c) of the sclerotomy site, five cases within 2 o/c, two cases within 8 o/c and one case within 4 o/c. Interestingly, 15 of 18 SRRB cases (83 %) and 14 of 23 non-SRRB cases (61 %) were found in the superior peripheral retina.

Univariate analyses were performed to determine relationships between various factors and the occurrence of IPRBs (Table 2). The 20-gauge conventional vitrectomy procedure and operation time significantly influenced the occurrence of IPRBs. Multivariate analysis revealed that significant risk factors for IPRBs were intraoperative PVD induction (OR=1.97, P=0.04), the 20-gauge vitrectomy procedure (OR=2.91, P=0.03), and operation time (OR=1.01, P<0.01) (Table 3).

Data from patients with macular disease were grouped by condition, including macular hole, epiretinal membrane, vitreomacular traction, and macular edema. The incidence rate of the IPRBs in macular disease was 2.8 % (16 of 570 cases), which was slightly lower than the 3.0 % (41 of 1,375

Table 2 Univariate analysis to examine the correlation between clinical and surgical factors and iatrogenic peripheral Retinal Break (IPRB)

Categorical variables	Incidence rate of IPRB (%)	OR (95 % CI)	*P* value
Gender			
Male	23/619 (3.7 %)	1.60 (0.85–2.96)	0.15[a]
Female	18/756 (2.4 %)		
Ocular dominance			
Right	26/711 (3.7 %)	1.64 (0.86–3.13)	0.13[a]
Left	15/664 (2.3 %)		
Lens state			
Pseudophakia/Aphakia	8/260 (3.1 %)	1.04 (0.48–2.28)	0.92[a]
Phakia	33/1115 (3.0 %)		
Surgeon			
PKH	32/936 (3.4 %)	1.69 (0.83–3.57)	0.16[a]
WSJ	9/439 (2.1 %)		
Gauge of vitrectomy			
20-gauge	25/402 (6.2 %)	3.97 (2.09–7.51)	< 0.001[a]
23-gauge	16/973 (1.6 %)		
Combined cataract operation			
Yes	14/624 (2.2 %)	0.62 (0.32–1.18)	0.14[a]
No	27/751 (3.6 %)		
PVD induction			
Yes	17/404 (4.2 %)	1.73 (0.92–3.26)	0.09[a]
No	24/971 (2.5 %)		
Age		0.98 (0.96–1.01)	0.21[b]
Operation time		1.02 (1.01–1.02)	< 0.001[b]

[a] *P* values relate to Pearson's chi-square test

[b] *P* values relate to binary logistic regression test

OR odds ratio; *CI* confidence interval; *PVD* posterior vitreous detachment

cases) incidence in all patients. Univariate analysis again revealed that 20-gauge vitrectomy (OR=3.14, P=0.03), intraoperative PVD induction (OR=3.60, P=0.01), and operation time (OR=1.03, P<0.001) were significantly associated with IPRB occurrence. The odds ratio of operation time means that the risk of IPRB increased by a factor of 1.03 when the operation time was increased by 1 min. Multivariate analysis also confirmed this finding (20-gauge vitrectomy, OR=3.42, P=0.03; operation time, OR=1.02, P<0.01; PVD induction, OR=3.85, P=0.01).

Table 3 Multivariate analysis for associations between clinical and surgical factors and iatrogenic peripheral retinal break

Variables	Iatrogenic peripheral retinal break		
	OR	95 % CI	*P* value[a]
Gender	1.43	0.75–2.71	0.28
Ocular dominance	1.73	0.90–3.35	0.10
Surgeon	1.60	0.23–1.72	0.36
Combined cataract operation	1.44	0.72–2.90	0.31
PVD induction	1.97	1.02–3.78	0.04
Gauge of vitrectomy	2.91	1.11–7.62	0.03
Operation time[b]	1.01	1.00–1.02	< 0.01

[a] *P* values relate to multiple binary logistic regression analysis test

[b] Risk of IPRB increased by a factor of 1.01 when operation time was increased by 1 min

OR odd ratio; *CI* confidence interval

Discussion

An IPRB is considered a serious complication of the vitrectomy procedure, because it could likely lead to retinal detachment and, potentially, severe visual deterioration. There have been many reports for the incidence of IPRBs in 20-gauge, 23-gauge, and 25-gauge vitrectomy procedures [6–16]. However, a large variation exists in the reported incidence of peripheral retinal breaks among studies. With the 20-gauge vitrectomy, the reported incidence ranges from 3.1 % to 24.3 % [6–9, 11]. In the 23- and 25-gauge TSV, it ranges from 0 % to 15.8 % [10, 12–16]. The large variation may result from different definitions of IPRB, different indications for vitrectomy, different surgical methods, and different surgical skill levels.

It seems that using small-gauge TSV with a microcannula system decreases IPRB incidence compared with using a 20-gauge conventional system. Territo et al. [22] reported that using a cannulated vitrectomy system dramatically reduces the incidence of sclerotomy site tears from 7.7 % to 1.0 %. There have also been several reports comparing the incidence of IPRB between 20-gauge and 23-gauge or 25-gauge vitrectomy systems [17–19]. Nakano et al. [18] reported that the incidence rates of IPRB were 1.1 % (2 of 176 eyes) in 23-gauge vitrectomy and 8.5 % (13 of 153) in 20-gauge vitrectomy procedures performed for idiopathic macular holes and idiopathic epiretinal membranes ($P<0.01$). Issa et al. [19] documented that there was a significant reduction in the SRRB incidence from 16 % (14 of 85 eyes) in 20-gauge vitrectomy procedures to 5 % (4 of 85 eyes) in 23-gauge vitrectomy procedures in patients with proliferative diabetic retinopathy ($P=0.02$). These results are in agreement with our data that the incidence rate of IPRBs are 1.6 % (16 of 973 eyes) in 23-gauge TSV procedures and 6.2 % (25 of 402 eyes) in 20-gauge vitrectomy procedures ($P<0.001$).

We believe that 23-gauge TSV (with cannula system) can reduce vitreous base traction and incarceration, thereby reducing the incidence of IPRB, especially SRRB. Our incidence of SRRB was 0.7 % (7 of 973 eyes) in 23-gauge and 2.7 % (11 of 402 eyes) in 20-gauge vitrectomies ($P<0.01$). Intraoperative SRRB can result from vitreous traction, created during instrument insertion and removal. Vitreous gel can also become trapped within the sclerotomy site after the procedure. The use of small gauge cannulas creates a mechanical barrier around the sclerotomy site, effectively reducing traction during maneuvers of surgical instruments. The high incidence of IPRB (21.1 %) in 20-gauge vitrectomies on patients with subretinal hemorrhage might support our theory. These cases needed large, angled vitrectomy instruments that might cause high amounts of vitreous traction around sclerotomy sites, especially given that these cases often require more in/out movement of surgical instruments and have a prolonged surgical time.

Along the same lines of thinking, superior sclerotomy sites are often exposed to more frequent instrument insertion and removal than inferior ones. Moore et al. [6] reported that breaks were more likely to occur superiorly, with 69 % of all breaks (45 of 65 breaks) in this quadrant, regardless of category. Ramkissoon et al. [8] documented that 41.5 % of breaks occurred between the 2 and 10 o'clock positions ($P<0.01$). In agreement with these results, we observed that 71 % (29 of 41 eyes) of IPRBs and 83 % (15 of 18 eyes) of SRRBs occurred on the superior side.

Our study showed that the incidence rate of non-SRRB was lower in 23-gauge vitrectomies (0.9 %, 9 of 973 eyes) compared with 20-gauge vitrectomies (3.5 %, 14 of 402 eyes) ($P<0.01$). Tan et al. [10, 11] also reported that, for macular diseases, the incidence of SRRB in 25-gauge vitrectomies (5.1 %) was much lower than that in 20-gauge surgeries (17.0 %), but that the incidence of breaks elsewhere was about equal between the two (11.9 % in 25-gauge vs. 9.6 % in 20-gauge). However, it is inappropriate to compare our study with Tan et al. [11] as their study included only macular disease. Our study included various indications for vitrectomy (including macular diseases) and the incidence rate of IPRB was much lower. We believe that smaller instruments and slower fluidics in 23-gauge vitrectomy make it possible to perform meticulous surgical procedure while reducing the occurrence of both SRRBs and non-SRRBs.

Intraoperative PVD induction was found to be an independent risk factor for IPRB in the multivariate analysis ($OR=1.97$, $P=0.04$). There have been several reports that have revealed PVD induction as a risk factor of IPRB [8, 9, 11, 18]. In a series of 645 eyes undergoing 20-gauge vitrectomy, Ramkissoon et al. [8] reported that eyes that had a PVD induced had 2.9 times greater odds of developing an IPRB ($P<0.001$). Chung et al. [9] documented that the incidence of retinal breaks was higher in patients undergoing surgery for macular holes than for epiretinal membranes (14.6 % vs. 6.9 %, $P=0.02$) and that the macular hole group had a higher rate of PVD induction than the epiretinal membrane group (76.6 % vs. 16.0 %). This helps to explain the difference in retinal break incidence. In our study, both subgroup univariate and multivariate analyses on vitrectomies performed for macular diseases also revealed that PVD induction is a risk factor. Additionally, we found that the incidence of IPRB in macular hole patients (4.6 %) was higher in comparison to epiretinal membrane (1.9 %), macular edema (2.4 %), and vitreomacular traction (0 %) patients. This observation supports the hypothesis that IPRBs are accompanied by PVD induction.

In our study, longer operation time was also a risk factor of IPRB, determined by both univariate and multivariate analyses. However, this interpretation requires caution because operation time is lengthened by the breakout of IPRBs. Nevertheless, we did not exclude operation time from analyses. The incidence of IPRBs was low so that average operation time would function as an independent factor, which might be associated with IPRBs. Therefore, it is reasonable to consider operation time as a risk factor of IPRBs in that a longer operation time is associated with more frequent instrument insertion and removal, which might also reflect the complexity of case.

Lens status was found to be unrelated to the occurrence of IPRB in our study. It is controversial whether phakia is a risk factor of IPRB [6–9, 23]. Al-harthi et al. [7] reported that 13 of 14 SRRBs (92.9 %) occurred in phakic eyes and Moore et al. [6] documented that phakic eyes (15.5 %, 35 of 226 eyes) are more likely to have breaks compared with pseudophakic and aphakic eyes (7.1 %, 13 of 182 eyes). Ramkissoon et al. [8] also reported that phakic eyes had 2.4 times higher odds of break formation than pseudophakic or aphakic eyes. However, Wimpissinger et al. [23] reported that one in 11 eyes, in which sclerotomy-related retinal detachment developed, was a phakic eye. In two series of 218 eyes and 177 eyes for macular diseases, phakia was not associated with IPRB [10, 11]. Here, both surgeons made the sclerotomy 3.5 mm from limbus in all surgeries, whether eyes were phakic or not. Therefore, our results are not confounded by sclerotomy site position changes, which are theorized to affect IPRB incidence. Further large, controlled studies are needed to understand better the relationship between phakia and IPRB.

Our study is unique in that it is one of the largest case series comparing IPRBs in 20-gauge and 23-gauge sutureless vitrectomies. Additionally, we included most indications for vitrectomy, better representing actual clinical outcomes of vitrectomy patients.

Our study does have several drawbacks. First, it is a retrospective study that has inborn limitations regarding bias control. Second, all 20-gauge surgeries were performed by one surgeon (KHP), but 23-gauge vitrectomies were performed by both. However, there was no difference in IPRB incidence of 23-gauge vitrectomy between the two surgeons, which suggests that surgeon factor might not have significant influence on the breakout of IPRBs. Third, the proportion of surgical indications was also somewhat different between 20-gauge and 23-gauge vitrectomy patients (Table 1). Fourth, we did not include postoperative IPRBs, so the reported incidence of IPRB might be relatively low comparing with previous studies that include postoperative IPRB. Lastly, we could not definitively determine the cause of the lower IPRB incidence. It might be due to the smaller sclerotomy size of the 23-gauge surgeries compared to the 20-gauge surgeries, or because a cannula system was used only in 23-gauge vitrectomies. Further studies comparing 23-gauge and 20-gauge vitrectomy, both with trocar systems, are necessary to determine the role that cannulas may play in decreasing IPRB rates.

In conclusion, we demonstrated a much lower incidence of IPRBs in 23-gauge TSV than in 20-gauge conventional vitrectomy. The induction of intraoperative PVD and longer operation times were also shown to be independent risk factors of IPRB.

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