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# International multi-center study of iatrogenic retinal tears in pars plana vitrectomy

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## Abstract

• **AIM:** To study and compare the effect of different surgical settings on the development of iatrogenic retinal tears (IRT) in conventional (20-gauge) and microincisional vitrectomy.

• **METHODS:** An international retrospective comparative study of 394 patients who had simple vitrectomy at three tertiary centers. Surgeries were performed by four retina surgeons using different viewing systems. Two groups of eyes were compared: microincisional vitrectomy (327 eyes) and conventional (67 eyes) vitrectomy. An iatrogenic tear was defined as the occurrence of one or more peripheral retinal tears during surgery or at any visit in the first 6wk postoperatively.

• **RESULTS:** Mean age was 67±12y and 55% were female. Iatrogenic tears occurred in 11/394 (2.8%) of eyes. The rate of tears was similar among different surgeons and viewing systems ( $P=0.93$  and  $P=0.76$ , respectively). Surgical indication, preexisting pseudophakia/aphakia, induction of posterior vitreous detachment (PVD) during surgery, and the use of triamcinolone acetonide didn't significantly affect the rate of tears ( $P>0.1$  for all factors). A higher rate of tears was found in the conventional group compared to the microincisional group (respectively, 7.5%, 1.8%,  $P=0.02$ ).

• **CONCLUSION:** The rate of IRT in vitrectomy is not significantly affected by surgical indication, preexisting

**PVD or pseudophakia, or use of triamcinolone or different viewing systems but is significantly higher in conventional vitrectomy. Microincisional platforms improve the safety of vitrectomy regardless of the viewing system used.**

• **KEYWORDS:** microincisional; vitrectomy; iatrogenic; retinal tear; 20-gauge

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## INTRODUCTION

Pars plana vitrectomy (PPV) has evolved over the past few decades and is the standard surgical procedure for the management of a wide range of vitreoretinal pathologies including retinal detachment, proliferative diabetic retinopathy (PDR), and macular conditions such as epiretinal membranes (ERMs) and macular holes (MHs). Iatrogenic retinal tears (IRT) may complicate PPV and may lead to rhegmatogenous retinal detachment (RRD) which necessitates further surgical management and may substantially affect the final visual outcome and patient satisfaction. Thus, understanding the circumstances and risk factors that may affect the development of IRTs in PPV can help surgeons make certain modifications in the surgical platform, technique, and instrumentation in order to minimize the chance of occurrence of retinal tears.

The documented incidence of IRTs after PPV is variable among studies and ranges from less than 1% to approximately 24%<sup>[1-2]</sup>. This inconsistency may be attributed to the lack of standardization of surgical technique among different surgeons and to other factors including surgical indication, type and location of the retinal breaks reported, instrument gauge, use of dyes during surgery, lens status, and the presence of preexisting posterior vitreous detachment (PVD) at time of surgery<sup>[1-3]</sup>.

The purpose of this study is to report the incidence and the effect of certain factors on the development of IRT in simple conventional (20 gauge) and microincisional vitrectomy surgery (MIVS).

## SUBJECTS AND METHODS

**Ethical Approval** This was an international multicenter retrospective study with the collaboration of several investigators affiliated to institutions in the United States, Jordan, and Israel. We were given approval to conduct the study by the institutional review board at each of the University of Louisville, KY, USA, the Jordan University of Science and Technology, Irbid, Jordan, and the Technion-Israel Institute of Technology, Haifa, Israel.

A retrospective chart review was performed on patients who underwent PPV at the ophthalmology department in each of the institutions between 2/2013 and 4/2016. We collected existing medical data and no patients' personal identifiers were recorded. Data collected included patient demographics and surgical information including indication of PPV, instrument gauge, dilated funduscopy before and after surgery, preexisting pseudophakia/aphakia, use of preservative-free triamcinolone acetate (TA) to visualize the vitreous during surgery, presence of preexisting PVD, viewing system used, name of surgeon, and occurrence of IRT with or without RRD during surgery and up to 6wk postoperatively. Exclusion criteria included incomplete medical records, follow up period of less than 6wk postoperatively, history of previous PPV, and the indication for the study PPV being RRD or a complex pathology with an inherent risk for the development of tears including advanced PDR, uveitis, trauma, and congenital malformations.

In all patients, standard 3-port PPV was performed by four different retina surgeons (Barak Y, Barr C, Saleh O, Schaal S) at three different ophthalmology centers. One type of vitrectomy machine was used (Stellaris PC<sup>®</sup>, Bausch+Lomb, Bridgewater, NJ, USA) with vitrectomy cutting rate values ranging from 2000-5000 cut per minute and vacuum values ranging from 150-400 mm Hg. Sclerotomies in conventional PPV were sutured and in microincisional PPV were sutureless except when a leak was occasionally detected at the end of surgery. In all eyes included in the study, a thorough examination of the peripheral retina was performed before ending the surgery either with a contact wide field lens or with indirect ophthalmoscopy with scleral indentation. Shaving of the vitreous base was not performed as a standardized surgical step, however, it was performed along with adequate argon laser retinopexy in all cases in which tears were discovered. When RRD occurred, PPV with retinal reattachment and tamponade was performed. An IRT was defined as the occurrence of one or more peripheral retinal tears during the surgery or at any visit in the first 6wk postoperatively, regardless of whether the IRT resulted in a RRD. We excluded tears developing at the posterior pole resulting from retinal scraping by Tano brush or peeling of ERMs and old retinal tears with pigmentary changes and/or laser retinopexy marks.

For studying the effect of different factors on the rate of IRT, eyes were divided into comparison groups according to the gauge of PPV surgery, the indication for surgery, the presence of pseudophakia/aphakia, the presence of PVD, the use of TA, the viewing system used, and the surgeon.

**Statistics** All data collected in the study were recorded onto an electronic database *via* Microsoft Excel 2007 (Microsoft Corporation). Statistical analyses were performed using Minitab version 16.2.4 (Minitab Inc., State College, PA, USA). We compared baseline characteristics of patients with and without IRT by using, whenever appropriate, Student's *t*-test for normally distributed variables or Kruskal-Wallis *H* test for non-parametric variables. We used Pearson Chi-square test for analysis of categorical variables. A *P* value of less than 0.05 was considered significant.

## RESULTS

Overall, 394 eyes of 394 patients fulfilled the inclusion criteria and were included in the final analysis. Microincisional PPV was performed in 327 eyes (25-gauge: 256, 23-gauge: 32, 27-gauge: 39) and 20-gauge PPV in 67 eyes. The mean age was 67±12y and 55% (*n*=218) were female. As demonstrated in Table 1, demographic parameters were similar among eyes with and without IRT.

The most common indication for PPV was ERM (48%, *n*=189), followed by MH (30%, *n*=117), vitreous hemorrhage (12%, *n*=47), vitreomacular traction syndrome (5%, *n*=19), central retinal artery occlusion (2%, *n*=9), submacular hemorrhage secondary to advanced age related macular degeneration (1%, *n*=5), symptomatic floaters (1%, *n*=4), and dislocated or dropped intraocular lens (1%, *n*=4). No significant association was found between ERM or MH and the rate of tears (*P*=0.74 and *P*=0.55 respectively). The proportion of eyes that had preexisting PVD or preexisting pseudophakia/aphakia at the time of surgery was similar in patients with and without IRT (*P*=0.76 and *P*=0.52, respectively).

IRTs were detected in 2.8% of the eyes (*n*=11). All tears were flap (horse-shoe) tears of variable sizes. In one eye, three IRTs developed (at 5, 7, and 11 o'clock positions) while a single tear occurred in the rest. Eight tears (62%) were within 2 clock hours of the sclerotomy sites while two occurred at the 6 o'clock position, and one at each of the 5 o'clock, 7 o'clock, and 12 o'clock positions. The IRTs were detected before the conclusion of surgery in 7 eyes (64%), a week after surgery in 3 eyes (27%) and about a month after surgery in 1 eye (9%). A significantly higher rate of tears was found in the 20-gauge PPV group (5 tears, 7.5%) than in the MIVS group (6 tears, 1.8%; *P*=0.02). One eye with a single tear progressed to RRD (0.3% of all eyes). The IRT was detected along with the RRD one week following 20-gauge PPV. The RRD was successfully treated with PPV and silicone oil tamponade. Table 2 depicts the intraoperative variables of eyes with and without IRT.

**Table 1 Demographic and baseline characteristics of all 394 patients with comparison between eyes with and without the development of IRT**

Parameters	Iatrogenic tear (n=11)	No iatrogenic tear (n=383)	P
Age (y)	66.2±12.8	66.8±11.8	0.87 <sup>a</sup>
Gender, female (%)	45.5	55.1	0.53 <sup>b</sup>
Ethnicity, ME/C/AA (%)	45/55/0	40/55/5	0.98 <sup>b</sup>
MH (%)	36	30	0.55 <sup>b</sup>
ERM (%)	36	48	0.74 <sup>b</sup>
Preexisting PVD at time of surgery (%)	64	45	0.76 <sup>b</sup>
Preexisting pseudophakia/aphakia at time of surgery (%)	63	73	0.52 <sup>b</sup>

IRT: Iatrogenic retinal tears; ME: Middle Eastern; C: Caucasian; AA: African American; MH: Macular hole; ERM: Epiretinal membrane; PVD: Posterior vitreous detachment. <sup>a</sup>Student's *t*-test; <sup>b</sup>Chi-square with Yates correction.

**Table 2 Intraoperative variables in all 394 patients with comparison between eyes with and without the development of IRT %**

Parameters	Iatrogenic tear (n=11)	No iatrogenic tear (n=383)	P <sup>a</sup>
20-gauge PPV	45	16	0.02
Triamcinolone acetonide used	64	71	0.74
Viewing system, BIOM/AVI/RESIGHT/EIBOS	46/18/18/18	38/32/19/12	0.76
Retina surgeons (Barak Y, Barr C, Saleh O, Schaal S)	36/27/18/18	43/26/17/14	0.93

IRT: Iatrogenic retinal tears; PPV: Pars plana vitrectomy; BIOM: BIOM<sup>®</sup> (OCULUS Surgical, Inc., Wetzlar, Germany); AVI: A.V.I.<sup>®</sup> (Advanced Visual Instruments, Inc., NY, USA); RESIGHT: Resight 700<sup>®</sup> (Carl Zeiss Meditec AG, Jena, Germany); EIBOS: EIBOS<sup>®</sup> (HAAG-STREIT SURGICAL, Wedel, Germany). <sup>a</sup>Chi-square with Yates correction.

Triamcinolone was used to visualize the vitreous in the majority of our patients (70%, *n*=277) but that didn't significantly affect the rate of IRT (*P*=0.74). Surgeries were performed by four retina surgeons each using a different type of contact or non-contact binocular panoramic indirect fundus viewing system (Table 2). The BIOM<sup>®</sup> platform was used in 38% of cases, the A.V.I.<sup>®</sup> in 32%, the Resight 700<sup>®</sup> in 19%, and the EIBOS<sup>®</sup> in 12%. The rate of IRT was similar among the different surgeons and the different viewing systems (*P*=0.93 and *P*=0.76, respectively).

## DISCUSSION

The overall rate of IRT in PPV was found to be 2.8% in our study, which is similar to rates documented by some studies of IRTs in conventional and MIVS<sup>[4-5]</sup>, but is considered relatively low when compared to other similar studies in the literature<sup>[1,3,6-7]</sup>. It is possible that such variability among studies may be partly attributed to differences in surgical techniques and settings or patient demographics. Additionally, the definition of an IRT may differ from one study to another. For example, Ehrlich *et al*<sup>[3]</sup> reported IRT in 29 out of 184 eyes which underwent PPV (15.7%) but included tears that occurred posterior to the equator, which accounted for almost half of the documented tears. Similarly, Tan *et al*<sup>[7]</sup> reported IRT in 28 out of 177 PPV cases (16%) but only 9 tears were sclerotomy-related. In our study, we excluded retinal tears posterior to the equator as such tears are usually a result of direct retinal injury during surgical manipulations in the macula and included in

our statistical analysis only IRTs located anterior to the equator, which are usually attributed to peripheral mechanical traction on the retina close to the vitreous base during exit and entry of instruments through the sclerotomies or vitreous incarceration within the sclerotomies<sup>[3,8]</sup>. Accordingly, our documented rates of 1.8% in MIVS and 7.5% in conventional PPV are in keeping with other similar reports from groups who adopted this definition of IRT. In addition, the distribution of our observed IRTs, with the majority being sclerotomy-associated, and the rest occupying both superior and inferior locations appears compatible with similar studies<sup>[4-5,9]</sup>.

The difference in the rate of IRTs between MIVS and conventional PPV in our study was statistically significant, which is consistent with many recent studies which compared these two surgical platforms<sup>[1-2,4-5,10-11]</sup>. It is postulated that the smaller sclerotomies and the cannulated ports used in MIVS offer safer passage for instruments with less tractional forces exerted on the vitreous base and may therefore reduce the incidence of sclerotomy-associated retinal tears<sup>[2,4,10,12]</sup>.

It is interesting to note that among the different conditions in our study the rate of IRT was similar. Most related investigations in this regard found increased rates of IRT in PPV for MH relative to PPV for ERM<sup>[1,6,13-16]</sup>. Based on the fact that most cases of MH repair require PVD induction during surgery, it is not surprising to find a parallel trend for a higher rate of IRT in numerous studies that investigated intraoperative induction of PVD<sup>[2,6-7,9-10,16-17]</sup>. Several reports, on the other

hand, found no difference in the rate of IRT for ERM or MH surgeries and no increased risk with intraoperative PVD induction<sup>[7,10,15]</sup>.

Most retinal breaks occur just posterior to the vitreous base and may not be readily visible to the surgeon especially in cases of macular surgery where the field of view is focused in the center. It is possible to improve visualization of the vitreous gel as well as other ocular transparent tissues by the use of vital dyes during PPV, a technique called chromovitrectomy<sup>[18]</sup>. One example of such a dye is TA. We wanted to investigate if such visual facilitation in the surgical technique may possibly play a role in reducing the likelihood of IRTs. Several case series have shown the intraoperative usefulness of TA in PPV<sup>[19-20]</sup>. Yamakiri *et al*<sup>[21]</sup> studied the effect of use of TA on the rate of complications, including IRTs, in 774 cases of PPV in Japan, and found that retinal tears were significantly less likely to occur in TA-assisted PPV. Covert *et al*<sup>[10]</sup>, in contrast, didn't find a statistical difference in the rate of IRT with the use of TA. Although more than two thirds of our PPV cases were TA-assisted, we found no lowered incidence of IRT in these eyes.

The last parameters we looked at were the viewing systems used in PPV and the operating surgeons. Each of our four different qualified retina surgeons used a different indirect viewing system. We found that neither the type of viewing system nor the surgeon who performed the surgery had a statistically significant effect on the rate of IRT. Varying conclusions exist in the literature in that regard. Some suggested that the operating surgeon may be a crucial factor in that rate of IRT, even more important than the preoperative diagnosis, whereas others found no significant connection<sup>[4,21]</sup>.

To the best of our knowledge, our report is the first to study the type of viewing system used in PPV as a potential factor affecting the rate of IRTs. In addition, our report is the first to include in the analysis all available gauges of vitrectomy platforms, including 39 cases of 27-gauge surgeries.

Limitations to our study include its retrospective nature with its inherent risks of bias, lack of randomization of patients to the gauge of surgery or viewing system, lack of standardization of the surgeon and surgical techniques, and method used for detection of the peripheral retinal tears. Nonetheless, several points of strength in our study can be mentioned including the extended follow up period of 6wk after surgery for detection of IRTs and/or RRD which, as reported by Wimpissinger and Binder<sup>[22]</sup>, may well develop after surgery, on average 37d postoperatively. We also excluded from analysis complex-pathology cases with inborn tendency for IRT such as proliferative retinopathies and uveitis to produce more accurate results. In addition, the number of cases in our series is reasonably high and the inclusion of almost forty cases of 27 gauge PPV is considered new.

To summarize, we investigated the development of iatrogenic peripheral retinal tears in 394 cases of simple vitrectomy surgeries indicated mostly for macular disease and found that the rate is significantly higher in 20-gauge compared to MIVS (7.5% vs 1.8%). We also report no significant association between the rate of tears and any of the following factors: indication for surgery, preexisting PVD, use of TA, the surgeon performing the surgery, and the viewing system used.

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All authors substantially contributed to the work and fulfilled the authorship criteria including concept and design, data acquisition, manuscript drafting, data analysis and interpretation, technical and administrative support, critical revision, and supervision.

**Conflicts of Interest:** Saleh OA, None; Al-Dwairi RA, None; Mohidat H, None; Jusufbegovic D, None; Nesmith B, None; Barak Y, None; Mimouni M, None; Schaal S, None.

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