BJO Online First, published on December 23, 2015 as 10.1136/bjophthalmol-2015-307654

Iatrogenic retinal breaks in ultrahigh-speed 25-gauge vitrectomy: a prospective study of elective cases

Marco Mura,[1,2,3] Francesco Barca,[1] Roberto Dell'Omo,[1] Francesco Nasini,[1,4] Enrico Peiretti[1]

[1]Department of Ophthalmology, Academic Medical Centre, University of Amsterdam, Amsterdam, The Netherlands
[2]The Wilmer Eye Institute, Johns Hopkins University School of Medicine, Baltimore, Maryland, USA
[3]The King Khaled Eye Specialist Hospital, Riyadh, Kingdom of Saudi Arabia
[4]Department of Surgical, Medical, Molecular and Critical Area Pathology, University of Pisa, Pisa, Italy

Correspondence to
Dr Marco Mura, Department of Ophthalmology, Academic Medical Centre, University of Amsterdam, Meibergdreef 9, Amsterdam 1105 AZ, The Netherlands; mmura1@jhmi.edu

Received 11 August 2015
Revised 9 November 2015
Accepted 30 November 2015

To cite: Mura M, Barca F, Dell'Omo R, *et al. Br J Ophthalmol* Published Online First: [*please include* Day Month Year] doi:10.1136/bjophthalmol-2015-307654

ABSTRACT

Background/Aims To evaluate the incidence of intraoperative retinal breaks in the ultrahigh-speed (UHS) 25-gauge vitrectomy system in elective vitreous-retina surgery cases.

Methods A prospective series of 1676 eyes of 1306 consecutive patients. All eyes underwent an UHS 25-gauge transconjunctival sutureless pars plana vitrectomy for elective cases such as idiopathic epiretinal membrane (586 cases), floaters (153), macular hole (385), vitreous macular traction syndrome (119), dropped nucleus or intraocular lens (84) and vitreous bleeding (82). Patients were followed up for a minimum of 6 months.

Results There were 1409 eyes involved in this study. Iatrogenic retinal breaks were found in 25 eyes (1.8%) during surgery. The majority were detected in cases where posterior vitreous detachment was induced during surgery (21 eyes; 2.8% of the patients), and in only four eyes (0.6%) with an already detached vitreous. In nine cases, rhegmatogenous retinal detachment developed during the follow-up. Patients who showed intraoperative retinal breaks were not in this group. Other complications during the follow-up included two cases of vitreous haemorrhage (0.1%), two cases of dislocated intraocular lens (0.1%), and 23 eyes with hypotony without any further complications.

Conclusions UHS 25-gauge transconjunctival sutureless vitrectomy is a safe procedure for treatment of elective vitreous-retina cases. The risk of developing iatrogenic breaks seems to be correlated with adhesion of the posterior vitreous hyaloid. Other complications, such as rhegmatogenous retinal detachment or hypotony, were similar to previous reports. No correlation was found between iatrogenic retina breaks and other complications.

INTRODUCTION

Despite improvements in surgical techniques, the development of intraoperative iatrogenic retinal breaks (IRBs) is still a significant complication of pars plana vitrectomy (PPV). The incidence of retinal breaks using standard vitrectomy has been reported at between 4% and 24%.[1–8] IRBs may result in postoperative rhegmatogenous retinal detachment (RRD) that may lead to poor outcomes after surgery.[1 5 9–11]

The highest cut rate for vitrectomy, commonly known as ultrahigh-speed (UHS) vitrectomy, is currently 7500 cpm. UHS vitrectomy can reduce the number of IRBs, minimise the vitreous turbulence and reduce the dynamic vitreoretinal traction.[12]

IRBs may be caused by several mechanisms during PPV, such as trocar insertion and dissection of the vitreous base. Induction of a posterior vitreous detachment (PVD) may also play a major role.[13 14] This study therefore sought to determine the incidence of IRBs in a prospective series of elective 25-gauge PPV cases, and to identify the possible causes of these breaks. Further complications were also recorded to determine possible correlations with iatrogenic tears.

METHODS

Of 1306 patients, 1676 eyes were prospectively selected from January 2013 to January 2015 in a single referral centre in Amsterdam, The Netherlands. The study protocol was approved by the local institutional review board, and all patients signed an institutional review board approved informed consent form. The study adhered to the tenets of the Declaration of Helsinki.

Any previous PPV or other procedures for retinal detachment (RD) were considered as exclusion criteria for the study. Finally, 1409 out of 1676 eyes were enrolled.

The patients underwent elective surgery with UHS 25-gauge transconjuctival sutureless PPV for the following diseases: idiopathic epiretinal membrane (ERM) (586 cases), floaters (FL) (153 cases), macular hole (MH) (385 cases), vitreous macular traction syndrome (VMTS) (119 cases), dropped nucleus or intraocular lens (DROP NU-IOL) (84 cases) and vitreous bleeding (VIT BL) (82 cases). The following data were recorded: age, sex, indication of surgery, best-corrected visual acuity (BCVA), preoperative and postoperative intraocular pressure, and slit-lamp biomicroscopy of the anterior and posterior segments. During the ophthalmic evaluation, the periphery was accurately checked with an indirect ophthalmoscope (+20 dioptre lens), and with a scleral depressor. Retinal defects or lattice degenerations were recorded in the patients' medical charts for either cryotherapy or laser photocoagulation at the time of surgery. Each surgery was performed by a single surgeon (MM) after a referral visit, and a waiting time between the visit and the surgery of 2–6 weeks.

Of 1409 patients, 732 (52%) had phakic eyes and 677 (48%) had pseudophakic or aphakic eyes. Patients with phakic eyes (642) had cataract extraction during the follow-up. No combined surgery was performed. At the end of the follow-up, 168 patients still had phakic eyes. The 25-gauge PPV procedures were all performed using the Alcon Constellation Ultrahigh-Speed Vitrectomy 25-gauge total pack (Alcon, Fort Worth, Texas, USA). A BIOM viewing system (Oculus, Wetzlar, Germany) was used for posterior visualisation. All eyes received a core and partial peripheral vitrectomy under indentation. Any suspicious cases of vitreous attachment to the optic disc were stained with triamcinolone and PVD was induced with the vitrectomy probe in a cutting mode off and a suction rate of 650 mmHg. Every procedure was performed using a fixed cut rate of 5000 cuts per minute (cpm). The vacuum was set between 500 and 650 mmHg during the core vitrectomy, and between 20 and 300 mmHg during peripheral vitreous removal.

Surgical procedures varied after vitreous removal, depending on the pathologies. The peeling of any ERM and internal limiting membrane (ILM) with 25-gauge Eckhardt forceps (DORC, Zuidland, The Netherlands) was performed in all cases of ERM, MH and VMTS. A plano-concave contact lens was used for macula surgery visualisation. Every MH and VMTS involved 20% SF6 tamponade. In all other cases, air or 20% SF6 were chosen as endotamponade agents at the time of surgery.

After completing the vitrectomy, all patients underwent a meticulous and total examination of the periphery with a scleral indentation under wide-field indirect visualisation. Breaks that were not present at the preoperative fundus examination were considered iatrogenic breaks, but if the break was round or had substantial underlying pigment surrounding it, it was categorised as preexisting. Breaks were treated with cryotherapy or photocoagulation and location of all breaks was recorded. Other types of peripheral retinal pathology (ie, lattice degenerations) were treated with cryotherapy or photocoagulation but was not considered iatrogenic.

Primary outcome measure was the incidence of IRBs. Secondary outcome measure was the incidence of any further complications such as postoperative RRD within 6 months of vitrectomy, hypotony or endophtalmitis. MedCalc V.1.5.1 (Medcalc software, Mariakerke, Belgium) was used for statistical analyses. The data were analysed using Fischer's exact test, the χ^2 test, the Friedman test and the Wilcoxon test.

RESULTS

Baseline characteristics of the 1409 eyes are summarised in table 1. Women (725) and men (684) with a median age of 72 years (mean 70.7±8.9 years) were observed for a mean of 17.4±6.0 months with a minimum follow-up of 6 months (range 6–31 months). Eyes were phakic (732 eyes; 52%), and pseudophakic or aphakic (677 eyes; 48%) at the time of surgery. Median preoperative BCVA was 20/160 (logMAR 0.9 ±0.3), and median postoperative BCVA at the end of the follow-up was 20/40 (logMAR, 0.3±0.3).

Vitrectomy for ERM was performed in 586 cases. IRBs were observed at the end of surgery in 11 (1.9%) cases. Eight breaks (4.2%) occurred in eyes when PVD was induced (32.3%). The relationship between induced PVD and the occurrence of an IRB was statistically significant (p=0.0066). As a further complication, in the subseries of eyes with ERM, four eyes (0.7%) developed a postoperative RRD; no patient who showed IRB was in this group. No other complications were observed.

There were 153 FL collected during the study. IRBs were present at the end of the surgery in five (3.3%) cases. Though all breaks were observed in cases with induced PVD (51.6%), the relationship between induced PVD and the occurrence of an intraoperative RB was not significant (p=0.05908). As a further complication in eyes with FL, two eyes (1.3%) developed a postoperative RRD, no patient who showed an IRB was in this group. No other complications occurred.

There were 385 eyes with MH that underwent a vitrectomy with ILM peeling and 20% SF6 gas injection. IRBs were observed in six (1.6%) eyes. PVD was induced in 336 (87.3%) cases. No statistical difference was found between cases with and without PVD induction, and with the presence of any intraoperative breaks (p=1.0000). Postoperative RRD was found in two cases (0.5%), and none of these eyes had any IRB during the elective surgery.

There were 119 eyes with a diagnosis of VMTS that were selected for this study. PVD was induced in 106 cases (89.1%). Two eyes (1.7%) showed intraoperative retinal breaks. In all these cases, PVD was induced during surgery, but there was no significant correlation between the surgical removal of the posterior hyaloid and IRB (p=1.0000). No further complications were noted in this group.

In the DROP NU-IOL group (84 eyes), after a core and peripheral vitrectomy, the IOL was positioned in the sulcus if possible, otherwise an Artisan implant was placed in the anterior chamber. PVD was induced in 16 eyes (19.9%). No IRBs were reported. One eye (1.2%) developed a postoperative RRD.

Patients with VIT BL (82 eyes) underwent a vitrectomy with laser photocoagulation or cryoretinopexy for cases of retina tears or diabetic retinopathy. Only one eye with an already detached vitreous was found to have an iatrogenic retinal tear. None of the patients in this group developed a postoperative RRD. Complications are reported in table 2.

Twenty-five eyes (1.8%) showed the presence of an IRB during elective surgery. The induction of PVD was performed in 749 eyes (53.2%). IRBs were detected in 21 (2.8%) eyes in the induced PVD group and in four (0.6%) eyes where the vitreous was already detached. In this group, there was a higher frequency of IRB in eyes with still attached vitreous, and the difference was significant (p=0.0018, χ^2 test).

Table 1 Baseline characteristics (n=1409)

Mean age, years (±SD)	70.7±8.9
Mean follow-up, months (SD)	17.4±6.0
Sex	
Male	684 (48.5%)
Female	725 (51.5%)
Operated eye	
Right	719 (51%)
Left	690 (49%)
PVD	
Yes	660 (46.8%)
No	749 (53.2%)
Lens status	
Phakic	732 (52%)
Pseudophakic/aphakic	677 (48%)

PVD, posterior vitreous detachment.

Table 2 Overall complications

Intraoperative	25 (1.8%)
Retinal break	25 (1.8%)
Postoperative	35 (2.5%)
Hypotony	23 (1.6%)
Retinal detachment	9 (0.6%)
Vitreous haemorrhage	2 (0.1%)
Dislocated IOL	1 (0.1%)
Overall	60 (4.3%)

IOL, intraocular lens

Table 3 Incidence of iatrogenic retinal breaks per diagnosis

		Posterior vitreous detachment		Breaks	
Diagnosis	No. eyes	iPVD	No iPVD	iPVD	No iPVD
ERM	586	189 (32.3%)	397 (67.7%)	8 (4.2%)	3 (0.8%)
FL	153	79 (51.6%)	74 (48.4%)	5 (6.3%)	0
MH	385	336 (87.3%)	49 (12.7%)	6 (1.8%)	0
VMTS	119	106 (89.1%)	13 (10.9%)	2 (1.9%)	0
DROP NU-IOL	84	16 (19.0%)	68 (81.0%)	0	0
VIT BL	82	23 (28.0%)	59 (72.0%)	0	1 (1.7%)
TOTAL	1409	749 (53.2%)	660 (46.8%)	21 (2.8%)	4 (0.6%)

DROP NU-IOL, dropped nucleus or intraocular lens; ERM, epiretinal membranes; FL, floater; iPVD, induced posterior vitreous detachment; MH, macular hole; VIT BL, vitreous bleeding; VMTS, vitreomacular traction syndrome.

The occurrences of IRB for different retinal pathologies and other results are summarised in table 3. In each group, the difference was not significant, except for the ERM group (p=0.0066). The IRBs were located in the periphery, without quadrant preference, and just one of them was correlated with the sclerotomy sites; all other breaks were located more than one optic disc diameter from the trocar insertion (table 4).

There were only nine cases (0.6%) of postoperative RRD. Their main features are reported in table 5. Five cases of RRD occurred in patients with pseudophakic/aphakic eyes. However, the correlation with the lens status was not significant (p=0.7451). PVD was induced in four of these cases. The correlation between induced PVD and postoperative RRD was not significant (p=0.7417). In six patients, postoperative breaks have been identified in the superior quadrants, in three patients in the inferiors, without relations with the previous sclerotomy. Moreover, none of the detachments occurred in patients with breaks that were identified intraoperatively.

Other complications included two cases (0.1%) of vitreous haemorrhage that resolved spontaneously within 4–6 weeks, and two cases (0.1%) of a dislocated IOL that required a second operation for repositioning. There were 23 eyes with hypotony: 4 cases with collapsed eye walls were sutured, the remaining 19 cases resolved within a week. None of the cases developed any sign of endophtalmitis during the follow-up.

Table 4 Overall retinal breaks by diagnosis (n=25)

Diagnosis	Eye	Quadrant	iPVD	Post. RRD
ERM	R	ST	N	N
ERM	R	SN	Y	N
ERM	R	IT	Y	N
ERM	R	IN	Y	N
ERM	R	ST	Y	N
ERM	L	SN	N	N
ERM	L	ST	Y	N
ERM	L	IN	N	N
ERM	L	IT	Y	N
ERM	L	SN	Y	N
ERM	L	IT	Y	N
FL	R	IN	Y	N
FL	R	SN	Y	N
FL	R	ST	Y	N
FL	L	SN	Y	N
FL	L	IN	Y	N
MH	R	IT	Y	N
MH	R	SN	Y	N
MH	L	ST	Y	N
MH	L	IT	Y	N
MH	L	SN	Y	N
MH	L	ST	Y	N
VMTS	R	IN	Y	N
VMTS	L	IT	Y	N
VIT BL	R	IT	N	N

ERM, epiretinal membranes; FL, floater; IN, inferonasal; iPVD, induction of posterior vitreous detachment; IT, inferotemporal; L, left; MH, macular hole; Post. RRD, postoperative rhegmatogenous retinal detachment; R, right; SN, superonasal; ST, superotemporal; VIT BL, vitreous bleeding; VMTS, vitreomacular traction syndrome; Y, yes.

Table 5 Overall retinal detachment by diagnosis (n=9)

Diagnosis	Lens status	Eye	Tamponade	iPVD
ERM	PS	OD	Air	Y
ERM	P	OD	Air	Y
ERM	PS	OS	Air	N
ERM	P	OS	Air	N
FL	PS	OS	Air	Y
FL	P	OS	Air	N
MH	P	OS	20% SF6	N
MH	PS	OS	20% SF6	Y
DROP NU-IOL	A	OS	Air	N

20% SF6, 20% sulfur hexafluoride; A, aphakia; DROP NU-IOL, dropped nucleus or intraocular lens; ERM, epiretinal membrane; FL, floater; iPVD, induction of posterior vitreous detachment; MH, macular hole; OD, ocular dexter; OS, ocular sinister; P, phakic; PS, pseudophakia; Y, yes.

DISCUSSION

The occurrence of IRB remains an important complication after PPV for elective cases.[15] Excessive vitreous traction on the retina is the leading cause of such breaks. Several mechanisms can cause abnormal vitreoretinal traction, including manipulation of the insertion and removal of surgical instruments during surgery, or the incarceration of vitreous fibres in the sclerotomies. Abnormal suction on the vitreous base during shaving or PVD induction can also be a causative factor.[13]

The first two mechanisms are responsible for sclerotomy-related retinal breaks.[16] The aim of the 25-gauge cannulated system is to prevent developing breaks at the sclerotomies sites. This was confirmed by reports that the 20-gauge system was associated with a higher risk of sclerotomy-related retinal breaks (17.4%)[16] compared with the cannulated 25-gauge system (5.1%).[13] In the present study of elective cases, one sclerotomy-related break was observed. Traction exerted by the vitrectomy probe during cutting and aspiration could be another possible cause of IRB. Recent studies have reported that smaller gauge instrumentation and high cutting rates should theoretically be safer, by increasing the fluidic stability and minimising the vitreous turbulence.[12 17 18]

IRB can also be caused by infusion fluid, occurring during the fluid–air exchange surgical step.[15] Intraoperative retinal breaks are also related to PVD induction.[10 13] In the present study, the rate of IRBs was strongly associated with the induction of PVD during surgery. Twenty-one of 25 breaks (84%) occurred in eyes in which PVD was induced (p=0.0018, χ^2 test). For each analysed subgroup, more breaks were found when PVD was induced during surgery. The highest frequency of IRBs was found in the FL and ERM groups (6.3% and 4.2%, respectively) (table 3).

Hikichi *et al*[19] and Issa *et al*[20] postulated that when induction of PVD is the same and independent of the gauge used, the incidence of RB related to this surgical step is similar for every gauge (15–20%). They reported a significant positive relationship between PVD induction and the occurrence of IRB. It is of interest to compare the retinal break detection rates between eyes in which the PVD was induced during surgery (2.8%) and the rates of natural causes of RB in symptomatic PVD with ageing (7.3%).[21]

Due to a greater adhesion of the vitreous at the inferior quadrants, RBs have been reported to tend to develop at inferior quadrants when induction of PVD is necessary.[16] The analysis of the induced PVD subgroups did not confirm this: 11 breaks were observed in the superior quadrants, 10 breaks in the inferiors (table 4). The small calibre of the instrument reduces the so-called 'sphere of influence' which is the amount of vitreous engaged in the port and improved fluidics makes the PVD induction a more precise and controlled manoeuvre compared with older vitrectomy systems.[22 23] This feature associated with gently tangential motions of the cutter above the optic disc rim allows a more natural detachment of the posterior vitreous cortex. No active pulling of the vitreous cortex was applied and no detachment of the vitreous in adherent areas was attempted, but in those cases the vitreous was just trimmed short to minimise break formation during PVD induction. Some authors have speculated that intraoperative and postoperative retinal breaks and postoperative detachments are the result of an insufficient peripheral vitrectomy with the more flexible 25-gauge system.[24 25] However, the present study is not consistent with this possibility because our technique in all cases does not include systematic removal of the vitreous base. Our cases underwent indentation and 360° examination of the peripheral retina, with cryotherapy or laser therapy applied to all breaks and to any of the suspicious areas. This is considered essential in maintaining low rates of postoperative RD. Postoperative RRDs were noted in only nine cases (0.6%), and none of them were in patients where the breaks occurred intraoperatively: incomplete removal of peripheral vitreous may have caused development of RD. Notably, PVD was induced in just four of these postoperative RRDs. Furthermore, correlations with previous small retinal defects or the presence of lattice degeneration and IRBs were not found to be significant. Taken together, the UHS 25-gauge vitrectomy is associated with a small rate of intraoperative retinal breaks which rises by induction of PVD during surgery as already described in the literature.[14]

The incidence of RBs using standard 20-gauge vitrectomy has been reported to range between 4% and 24%,[1–8] with consequential RRD occurring in 1–14% of cases.[1 5 9–11] Ramkissoon *et al*[1] reported a high risk of iatrogenic breaks (15.2%) using a standard 20-gauge system, and Tan *et al* [13] reported 16% iatrogenic breaks with the standard 25-gauge system. Rizzo *et al*[14] reported a lower incidence of intraoperative retinal breaks using the UHS 25-gauge 5000 cpm compared with the standard 25-gauge 1500 cpm (1.7% vs 21.7%, respectively), strongly suggesting that high-frequency cutting is critical in avoiding IRB. This is due to the improved fluidics stability of the UHS vitrectomy. Fluidics stability depends on the following simple equation:

$$\text{Length of pull (of collagen fibres)} = \text{flow rate/lumen area/cut rate}$$

If the flow rate is increased, vitreous traction is increased, decreasing safety. Conversely, if you increase the cut rate, you decrease the length of pull of collagen fibrils, decrease the vitreous traction and increase safety. Also the higher the gauge, the lower the pull of vitreous. This concept, introduced by Steve Charles, is called 'port-based flow limiting'.[23] In the present study, 1409 eyes were treated using the new UHS 25-gauge 5000 cpm, with 25 IRB (1.8%). This is a lower rate compared with studies in the literature using lower-speed cutting.[14 19]

Contributors MM, FB, RDO: design and conduct of the study. MM, FB, RDO, EP: data collection. MM, FB, RDO, FN, EP: management, analysis, interpretation of the data. MM, FB, RDO, FN, EP: writing the manuscript. MM, FN, EP: critical revision and final approval of the manuscript.

Competing interests None declared.

Ethics approval Local institutional review board.

Provenance and peer review Not commissioned; externally peer reviewed.

REFERENCES

1 Ramkissoon YD, Aslam SA, Shah SP, *et al*. Risk of iatrogenic peripheral retinal breaks in 20-G pars plana vitrectomy. *Ophthalmology* 2010; 117:1825–30.
2 Theocharis IP, Alexandridou A, Gili NJ, *et al*. Combined phacoemulsification and pars plana vitrectomy for macular hole treatment. *Acta Ophthalmol Scand* 2005;83:172–5.
3 Chung SE, Kim KH, Kang SW. Retinal breaks associated with the induction of posterior vitreous detachment. *Am J Ophthalmol* 2009;147:1012–16.
4 Moore JK, Kitchens JW, Smiddy WE, *et al*. Retinal breaks observed during pars plana vitrectomy. *Am J Ophthalmol* 2007;144:32–6.
5 De Bustros S, Thompson JT, Michels RG, *et al*. Vitrectomy for idiopathic epiretinal membranes causing macular pucker. *Br J Ophthalmol* 1988;72:692–5.
6 Carter JB, Michels RG, Glaser BM, *et al*. Iatrogenic retinal breaks complicating pars plana vitrectomy. *Ophthalmology* 1990;97:848–53; discussion 54.
7 Sjaarda RN, Glaser BM, Thompson JT, *et al*. Distribution of iatrogenic retinal breaks in macular hole surgery. *Ophthalmology* 1995;102:1387–92.
8 Krohn J. Duration of face-down positioning after macular hole surgery: a comparison between 1 week and 3 days. *Acta Ophthalmol Scand* 2005;83:289–92.
9 Wimpissinger B, Binder S. Entry-site-related retinal detachment after pars plana vitrectomy. *Acta Ophthalmol Scand* 2007;85:782–5.
10 Guillaubey A, Malvitte L, Lafontaine PO, *et al*. Incidence of retinal detachment after macular surgery: a retrospective study of 634 cases. *Br J Ophthalmol* 2007;91:1327–30.
11 Rizzo S, Belting C, Genovesi-Ebert F, *et al*. Incidence of retinal detachment after small-incision, sutureless pars plana vitrectomy compared with conventional 20-gauge vitrectomy in macular hole and epiretinal membrane surgery. *Retina (Philadelphia, Pa)* 2010;30:1065–71.
12 Charles S. An engineering approach to vitreoretinal surgery. *Retina* 2004;24:435–44.
13 Tan HS, Mura M, de Smet MD. Iatrogenic retinal breaks in 25-gauge macular surgery. *Am J Ophthalmol* 2009;148:427–30.
14 Rizzo S, Genovesi-Ebert F, Belting C. Comparative study between a standard 25-gauge vitrectomy system and a new ultrahigh-speed 25-gauge system with duty cycle control in the treatment of various vitreoretinal diseases. *Retina (Philadelphia, Pa)* 2011;31:2007–13.
15 Bilgin AB, Türkoğlu EB, Ilhan HD, *et al*. Iatrogenic retinal breaks caused by infusion fluid during pars plana vitrectomy. *Can J Ophthalmol* 2015;50:77–9.
16 Tan HS, Lesnik Oberstein SY, Mura M, *et al*. Enhanced internal search for iatrogenic retinal breaks in 20-gauge macular surgery. *Br J Ophthalmol* 2010;94:1490–2.
17 Jalil A, Ho WO, Charles S, *et al*. Iatrogenic retinal breaks in 20-G versus 23-G pars plana vitrectomy. *Graefes Arch Clin Exp Ophthalmol* 2013; 251:1463–7.
18 Teixeira A, Chong LP, Matsuoka N, *et al*. Vitreoretinal traction created by conventional cutters during vitrectomy. *Ophthalmology* 2010;117: 1387–92.
19 Hikichi T, Kosaka S, Takami K, *et al*. Incidence of retinal breaks in eyes undergoing 23-gauge or 20-gauge vitrectomy with induction of posterior vitreous detachment. *Retina (Philadelphia, Pa)* 2012;32:1100–5.
20 Issa SA, Connor A, Habib M, *et al*. Comparison of retinal breaks observed during 23 gauge transconjunctival vitrectomy versus conventional 20 gauge surgery for proliferative diabetic retinopathy. *Clin Ophthalmol* 2011; 5:109–14.

21 Byer NE. Natural history of posterior vitreous detachment with early management as the premier line of defense against retinal detachment. *Ophthalmology* 1994;101:1503–13; discussion 13–4
22 Dugel PU, Zhou J, Abulon DJ, *et al*. Tissue attraction associated with 20-gauge, 23-gauge, and enhanced 25-gauge dual-pneumatic vitrectomy probes. *Retina (Philadelphia, Pa)* 2012;32:1761–6.
23 Charles S, Calzada J, Wood B. *Vitreous microsurgery*. 5th edn. Philadelphia: Wolters Kluwer/Lippincott Williams & Wilkins, 2011:18–28.
24 Chen E. 25-Gauge transconjunctival sutureless vitrectomy. *Curr Opin Ophthalmol* 2007;18:188–93.
25 Ibarra MS, Hermel M, Prenner JL, *et al*. Longer-term outcomes of transconjunctival sutureless 25-gauge vitrectomy. *Am J Ophthalmol* 2005;139:831–6.

Iatrogenic retinal breaks in ultrahigh-speed 25-gauge vitrectomy: a prospective study of elective cases

Marco Mura, Francesco Barca, Roberto Dell'Omo, Francesco Nasini and Enrico Peiretti

Br J Ophthalmol published online December 23, 2015