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RETINAL DISORDERS

Iatrogenic retinal breaks in 20-G versus 23-G pars plana vitrectomy

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Abstract
Background The purpose of this study was to compare the incidence of iatrogenic anterior retinal breaks in 20-G vitrectomy (PPV) with transconjunctival 23-G PPV.
Methods Retrospective, observational review study involving consecutive patients undergoing PPV in a single center in the UK during a 2-year period.
Results Sclerotomy-related entry-site breaks (ESB) were found in 50/628 (7.9 %) 20-G PPV cases and 5/296 (1.7 %) 23-G PPV eyes ($p<0.0001$*). Anterior non-sclerotomy iatrogenic breaks (ANSB) were present in 55/628 (8.7 %) 20-G PPV cases and 18/296 (6.1 %) 23-G PPV eyes ($p=0.19$). The incidence of total anterior iatrogenic breaks (ANSB+ESB) was 105/628 (16.7 %) for 20-G PPV and 23/296 (7.8 %) for 23-G PPV ($p=0.002$*). Univariate analysis showed that posterior vitreous detachment induction was the only risk factor significantly associated with the development of anterior retinal breaks for both 20-G and 23-G PPV. Multivariate logistic model of risk factors for development of iatrogenic retinal breaks demonstrated that 23-G PPV was the most important factor reducing the risk of anterior breaks ($p<0.0001$*).
Conclusions We report the largest series of patients undergoing 20-G and 23-G vitrectomy, where 23-G vitrectomy was associated with a significantly lower incidence of anterior iatrogenic retinal breaks.

The authors have full control of all primary data and agree to allow Graefe's Archive for Clinical and Experimental Ophthalmology to review their data if requested.

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Introduction

Since its inception nearly 40 years ago, three-port pars plana vitrectomy (PPV) has evolved to become the standard surgical procedure for a wide range of different retinal pathologies, including retinal detachment (RD), macular hole surgery, epiretinal membrane surgery, and proliferative diabetic retinopathy [1–5]. While generally considered a safe procedure, it is associated with certain risks, including post-vitrectomy retinal detachment [6]. Proposed mechanisms for post-vitrectomy retinal detachment include the development of "new" retinal breaks post-operatively, proliferative vitreoretinopathy (PVR) and over-application of cryotherapy leading to cryogenic necrosis. In addition, iatrogenic retinal breaks at the time of surgery may lead to post-vitrectomy retinal detachment. "Entry-site breaks", so-called because they typically originate in the anterior retina adjacent to the site of the sclerotomies, are believed to be caused by the insertion and removal of instruments that may drag adjacent vitreous, leading to the development of retinal tears at the posterior border of the vitreous base.

More recently, trans-conjunctival "sutureless" pars plana vitrectomy (TSV) has been introduced, with 23-G, 25-G, and 27-G techniques being described [7–9]. One of the claimed advantages of these newer techniques is that due to a smaller sclerotomy site and the presence of a "cannulated port" extending into the vitreous cavity, there will be a resultant reduced incidence of "entry-site breaks" and iatrogenic retinal tears [10]. As a result, one might expect the newer techniques to have a lower rate of retinal detachment following PPV.

We performed a retrospective, non-randomized, observational review study of the surgical electronic database of all patients undergoing both 20-G and 23-G PPV in a single center in the UK (Manchester Royal Eye Hospital) to compare the incidence of both "entry-site breaks" and "anterior" iatrogenic retinal tears" in 20-G PPV versus 23-G PPV, and also to compare the incidence of subsequent retinal detachment in both groups.

Methods

A retrospective case review of all consecutive patients undergoing three-port PPV (both 20-G and 23-G) at a single center (Manchester Royal Eye Hospital) between August 2008 and July 2010 (24 months) (with a minimum follow-up of 3 months) was undertaken using the electronic vitreoretinal surgical database (used to record the intra-operative findings). The described research adhered to the tenets of the Declaration of Helsinki. The IRB/Ethics Committee ruled that approval was not required for this study.

The following indications for surgery were excluded: rhegmatogenous retinal detachment, previous vitrectomy, or previous penetrating eye injury. The following information was collected from the electronic database: age, gender, pre-operative diagnosis, grade of surgeon, pre-existing peripheral retinal degeneration, PPV technique (20-G vs. 23-G), posterior vitreous detachment (PVD) pre-existing or induced intra-operatively, whether cataract surgery was undertaken at the time of the vitrectomy (combined phacovitrectomy), the presence of sclerotomy-related "entry-site" breaks (as judged by the surgeon at the time of surgery), occurrence of iatrogenic retinal tears in the anterior (pre-equatorial) retina (as judged by the operating surgeon at the time of surgery, and excluding iatrogenic retinal tears in the posterior retina, e.g., due to membrane delamination in proliferative diabetic retinopathy), the development of subsequent post-vitrectomy retinal detachment, and intra-operative findings of those patients having post-vitrectomy retinal detachment. Iatrogenic breaks were defined as full-thickness tears of the peripheral anterior neurosensory retina. Old breaks as suggested by features of chronicity, e.g., subretinal pigment deposition or sclerosed flaps were excluded.

Patients underwent either standard 20-G PPV or 23-G PPV based on individual surgical preference in a non-randomized fashion. All the surgeons used both 20-G and 23-G systems. The surgeries were done using the high-speed vitrectomy of the Bausch & Lomb Millennium System (enhanced by the D.O.R.C. Vitrectomy Transformer) with the help of non-valved cannulas. The "eiBOS" non-contact wide-angle viewing system (Moeller-Wedel GmbH, Rosengarten, Germany) was used to view the fundus. If the posterior vitreous hyaloid was attached, it would be detached by active aspiration (typically 300 mmHg) using the vitrectomy probe in "cutter-off" mode placed over the optic disc. The vitrectomies carried out in the department had a standard approach, especially for macular pathologies comprising of core vitrectomy and peripheral shave anterior to the equator without indentation. All cases underwent an internal search with scleral indentation to identify iatrogenic anterior retinal tears and sclerotomy-associated retinal tears towards the end of the procedure, and these were treated accordingly. The surgical cases were primarily performed either by a consultant vitreoretinal surgeon or a vitreoretinal fellow.

Statistical analysis

Demographic data, diagnostic case mix, grade of surgeon, presence or absence of PVD, and numbers of combined phacovitrectomy, were compared between the 20-G group and the 23-G group for any pre-existing differences (Student's *t* test for normative data and Mann–Whitney *U* test for non-parametric data). Pre-operative lens status was not available for those who did not have combined phacovitrectomy, and was not included in the analysis. Incidence of "sclerotomy-related iatrogenic breaks", "anterior iatrogenic retinal breaks", "all anterior iatrogenic breaks" and "post-vitrectomy retinal detachments" were compared between the 20-G PPV group and the 23-G PPV group (Chi-square test and Fisher's exact test). Finally, logistic regression analysis was undertaken, controlling for potential explanatory covariates. All analysis was undertaken using SPSS for Windows v11.0 (SPSS Inc, Chicago, IL, USA).

Results

In the 24-month study period, there were 628 20-G PPV eyes (610 patients) and 296 23-G PPV eyes (290 patients), which met the entry requirement of the study. Table 1 describes the demographic data, grade of surgeon, the induction of PVD, the numbers of combined phacovitrectomy, and the diagnostic case mix of the two groups. Pre-operative PVD was present in 45.7 % of 20-G PPV and 42.2 % of 23-G PPV cases. The major indications for vitrectomy were epiretinal membrane (ERM), macular hole, vitreo-macular traction, advanced proliferative diabetic retinopathy including vitreous hemorrhage and tractional retinal detachment (TRD), and retained lens fragments.

Sclerotomy-related entry-site breaks (ESB) were found in 50/628 (7.9 %) 20-G PPV cases and 5/296 (1.7 %) 23-G PPV eyes ($p<0.0001$* Fisher's exact test; odds ratio OR= 5.03, range: 1.99 to 16.33). Anterior non-sclerotomy

Table 1 The demographic data, grade of surgeon, induction of posterior vitreous detachment, numbers of combined phacovitrectomy and the diagnostic case mix of the two groups

	20-G PPV (n=628)	23-G PPV (n=296)
Age (mean±SD) (p<0.01 Student's t test)*	63±17 years	67±13 years
Gender (p=0.77, Chi-square test)	287 males (46 %)	133 males (45 %)
	341 females (54 %)	163 females (55 %)
Grade of surgeon (p<0.01, Chi-square test)*	378 consultants (60.2 %)	140 consultants (47.3 %)
Pre-op PVD (p=0.33 Chi-square test)	287/628 (45.7 %)	125/296 (42.2 %)
Combined phacovity (p=0.02 Chi-square test)*	246/628 (39.1 %)	141/296 (47.6 %)
Diagnostic case mix	Diabetic TRD: 55 (8.7 %)	Diabetic TRD: 5 (1.7 %)
	Diabetic V hge: 78 (12.4 %)	Diabetic V hge: 54 (18.2 %)
	ERM: 94 (14.9 %)	ERM: 60 (20.2 %)
	Macular hole: 174 (27.7 %)	Macular hole: 102 (34.4 %)
	Retained lens frag: 74 (11.8 %)	Retained lens frag: 7 (2.3 %)
	Vit hge (other): 60 (9.5 %)	Vit hge (other): 34 (11.5 %)
	VMT: 10 (1.6 %)	VMT: 15 (5.1 %)
	Miscellaneous: 81 (12.9 %)	Miscellaneous: 21(7.1 %)

PVD posterior vitreous detachment; *Pre-op* preoperative; *Phacovity* phacovitrectomy; *TRD* tractional retinal detachment; *Vit hge* vitreous hemorrhage; *ERM* epiretinal membrane; *frag* fragments; *VMT* vitreo-macular traction

iatrogenic breaks (ANSB) were present in 55/628 (8.7 %) 20-G PPV cases and 18/296 (6.1 %) 23-G PPV eyes (p=0.19; OR=1.48, range: 0.84 to 2.73). The incidence of total anterior iatrogenic breaks (ANSB + ESB) was 105/628 (16.7 %) for 20-G PPV and 23/296 (7.8 %) for 23-G PPV (p=0.002*; OR=2.38, range: 1.46 to 4.01). We did not see any learning curve; the retinal breaks in 23 G were evenly distributed throughout the study period.

Univariate analysis of risk factors for development of anterior iatrogenic breaks was carried out, and the only risk factor, which was significantly associated with the development of these breaks for both 20-G and 23-G PPV was the induction of PVD In the 20-G PPV group, PVD induction had been carried out in 67 out of 105 cases who developed retinal breaks and in 220 out of 523 cases without retinal breaks (p<0.0001*, OR=2.43). In the 23-G PPV cohort, PVD induction had been performed in 16 out of 23 cases with retinal breaks and in 109 out of 273 cases without retinal breaks (p=0.008*, OR=3.44). Combining the two groups, PVD induction had been carried out in 83 out of a total of 128 patients who developed anterior retinal breaks and in 329 out of 796 patients who did not have peripheral retinal breaks (p<0.0001*, OR=2.62). There was no effect of age, gender, grade of operating surgeon, or combining PPV with cataract surgery on the incidence of anterior retinal breaks.

Multivariate logistic model of risk factors for development of anterior iatrogenic break (ESB + ANSB) demonstrated that 23-G PPV was the most important factor reducing the risk of anterior breaks (p<0.0001*, OR=62.84). PVD induction was also found to be statistically significant (p=0.02*, OR=1.57) (Table 2).

Seven out of 628 20-G PPV patients developed retinal detachment (1.1 %) whereas 2 out of 296 23-G PPV patients had retinal detachment (0.67 %) (Chi-square test: p=0.73).

Discussion

Iatrogenic retinal breaks are an important complication of PPV and can lead to post-vitrectomy retinal detachment. The insertion and withdrawal of instruments into the globe can cause traction on the adjacent vitreous, and can lead to the formation of breaks at the posterior edge of the vitreous base. Another source of iatrogenic anterior tears is the induction of PVD during PPV. The incidence of retinal breaks following a 20-G PPV for macular disorders has been reported to be as high as 24.3 % in a study of 218 consecutive vitrectomies by Tan et al. [11]. The incidence of anterior retinal breaks in our 20-G cohort was 16.7 %, roughly half of which were sclerotomy-related.

Because of the tractional effect of instruments entering the vitreous cavity, a cannulated vitrectomy system may facilitate atraumatic entry of instruments into the eye, thus decreasing vitreous traction. There may also be better removal of vitreous around the sclerotomy site and the low aspiration rates of the small gauge vitrectomy cutter may also cause less traction on the retina [12]. Territo et al. have

Table 2 Multivariate logistic model of risk factors for development of anterior iatrogenic break (ESB's and ANSB's)

All surgeries (20 G and 23 G)	OR (CI)	p value
Gender (male=1)	1.17 (0.76 to 1.63)	0.57
Age (per year increase)	1.00 (0.99 to 1.07)	0.43
PVD induction (pre=1)	1.57 (1.06 to 2.32)	0.02
Combined phacovity (no=1)	1.32 (0.88 to 1.96)	0.18
Grade of surgeon (Cons=1)	1.11 (0.74 to 1.66)	0.59
Surgery (23 G=1)	62.84 (38.59 to 102.3)	<0.0001

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

shown that the use of cannulated vitrectomy system decreases the incidence of entry site retinal breaks especially with inexperienced surgeons [10].

There is a great variation in literature on the occurrence of anterior retinal breaks following TSV. In a series by Nakano et al. of 176 eyes undergoing 23-G PPV, no patient had entry-site break and only two patients had non-sclerotomy-related anterior retinal breaks, an overall incidence of 1.1 % [12]. Tan et al. presented a much higher incidence of 15.8 % in 177 eyes with 25-G PPV where 6.2 % were entry-site breaks and 10.7 % breaks were found elsewhere [13]. Ehrlich et al. looked at 184 consecutive patients undergoing both 23-G and 25-G PPV and found peripheral retinal breaks in 15.7 % where only 3.2 % were related to sclerotomies. Entry-site breaks were not related to the gauge of the instruments [14].

A few studies have compared the incidence of retinal breaks in 20-G PPV to the TSV. Gosse et al. showed that entry-site breaks occurred in 24 % of cases undergoing 20-G PPV and 8 % in the 23-G cohort having 50 patients in each group [15]. In a much larger recent retrospective study, Covert et al. compared the intraoperative retinal tear formation in standard 20-G procedure (204 patients) to the transconjunctival cannulated systems including 20-G, 23-G, and 25-G (211 patients); 23 % of the 20-G group had intraoperative retinal tears in contrast to only 3.3 % of the transconjunctival cannulated group, the difference being statistically significant [16]. This study indicates that rather than the gauge it is the presence of cannulated system which is protective against anterior retinal tear formation. The comparison of three different transconjunctival systems increases the generalizability of the findings but is a source of potential confounding factors. Our study only looks at the 23-G cannulated system, and compares it to the 20-G non-cannulated PPV, and has considerably higher numbers. In our 23-G cohort, sclerotomy-related retinal breaks occurred in 1.7 % and other anterior breaks were seen in 6.1 %, giving a total incidence of 7.8 %, which was significantly lower than the 20-G group (16.7 %). However, Hikichi et al. in their recent review of 122 eyes did not find any difference in the incidence rates of intraoperative retinal breaks between 23-G and 20-G group [17].

As with previous studies, our study confirms that PVD induction is a significant risk factor for anterior iatrogenic retinal breaks [13, 18, 19]. We did not, however, look at the location of the tears (superior versus inferior) where they occurred following PVD induction. Despite the differences in the iatrogenic anterior breaks seen in the two groups, there was no difference between the eventual retinal detachment rates (1.1 % in 20-G and 0.67 % in 23-G). This may be because most of these breaks were identified and treated at the time of surgery. Rizzo et al. have reported comparable results with an incidence of post-vitrectomy RD being 1.2 % after 20-G PPV, 1.8 % after 23-G PPV and 2.6 % after 25-G PPV [20], and Rasouli et al. giving a 1-year incidence of RD post 23-G PPV at 1.1 % [21].

Limitations of our study are that it is retrospective, and hence there are differences in the case mix. PPV for diabetic TRD was mostly 20-G although it constituted less than 10 % of the total surgeries. Iatrogenic peripheral retinal breaks may be more common in vitrectomy performed for diabetic TRD [22]. Also, the cited great variation in the literature of the incidence of anterior retinal breaks following vitrectomy underlines that the problem of such studies is the impossibility of standardization of surgical technique between various surgeons. However, our study is the largest number of cases reported to date which compares ESB's and ANSB's between 20-G and 23-G vitrectomies.

In conclusion, we report a study of 628 eyes undergoing 20-G PPV and 296 eyes undergoing 23-G transconjunctival sutureless vitrectomy, where 23-G PPV was associated with a significantly lower incidence of anterior iatrogenic retinal breaks and entry-site breaks. Induction of posterior vitreous detachment in both groups was an important factor contributing to retinal tears formation.

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Competing and commercial interests None.

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