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Pupillotonia after endolaser retinopexy during vitrectomy for retinal detachment: a prospective cohort study comparing circumferential and focal retinopexy

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ABSTRACT

Purpose To determine differences in postoperative pupil diameter in eyes that undergo pars plana vitrectomy (PPV) for rhegmatogenous retinal detachment (RRD) with endolaser retinopexy (ELR), comparing 360° vs focal ELR.

Methods Patients with uncomplicated RRD who underwent PPV were prospectively analysed regarding the postoperative pupil diameter difference (PDD) between the affected eye and the partner eye. Group 1 underwent 360° ELR and group 2 received focal ELR. Postoperative vision and complications, including redetachment rate, macular oedema and epiretinal membrane formation, were also compared.

Results A total of 72 patients, 42 in group 1 and 30 in group 2, were analysed. PDD, as observed at 6 weeks, was significantly greater than the preoperative values in both groups 1 and 2. It increased by a mean of 1±1.11 mm in group 1 and by 0.5±0.78 in group 2. This initial increase in PDD receded over time, but remained statistically significant in both groups, even at 6 months. The top 20% of patients with the largest PDD change comprised 13 out of 15 eyes from group 1, which was a statistically significant overrepresentation (p=0.0435).

Conclusions Moderate pupillotonia was induced post-ELR in vitrectomy and correlated to the extent of ELR. The pupillotonia effect of ELR was significantly less marked in pseudophakic eyes.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Endolaser retinopexy (ELR), a vital part of surgical repair of a vitreous detachment, can cause postoperative tonic pupil. The magnitude of the postoperative pupillotonia and the duration with respect to different ELR protocols has not been adequately researched.

WHAT THIS STUDY ADDS

⇒ Vitrectomy with ELR leads to moderate pupillotonia which lasts up to 6 months after surgery. More extensive ELR treatment causes more pupillotonia.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ The results of this study help put into context the moderate potential downsides of more aggressive endolaser treatment during vitrectomy.

INTRODUCTION

Pars plana vitrectomy (PPV) is the most frequently performed technique for treating rhegmatogenous retinal detachment (RRD).[1] During PPV, retinopexy is necessary to treat peripheral pathologies, such as retinal breaks and retinal degenerations. Identifying and sealing the causative retinal breaks during PPV is a critical step when treating RRD. Laser photocoagulation endolaser retinopexy (ELR) has become the gold standard for retinopexy during vitrectomy for the treatment of RRD.[2]

One surgical approach is to perform a 360°ELR anterior to the equator to prevent retinal redetachment after vitrectomy. It has been reported that 360° ELR in eyes vitrectomised for RRD can reduce the incidence of RD after silicone oil (SO) removal by 10%–30%.[3] More recently, a retrospective study of 151 cases, comparing circumferential and focal retinopexy, has reported a 75% reduction in the odds of retinal redetachment from 360° ELR.[4]

Despite the importance of ELR during vitrectomy for the treatment of RRD, laser photocoagulation can affect pupillary function, potentially due to damage afflicted towards the short and long ciliary nerves.[5 6] This can cause a dilated pupil postoperatively, which can lead to photophobia and decreased visual acuity due to excessive amounts of light entering the eye, causing light scattering and reduced depth of perception.

The primary aim of the study was to evaluate the effect of local and 360° ELR on pupil size, comparing treated and partner eyes. The secondary aims of this study were to investigate the effect of the two laser treatment methods on the redetachment rate, postoperative -corrected distance visual acuity (CDVA), and the postoperative integrity of the retina, specifically the presence of an epiretinal membrane (ERM) or macular oedema (ME).

METHODS

This study was designed as a prospective cohort study of consecutive PPV cases performed by four different surgeons between March 2018 and March 2020 for a predetermined period of 2 years.

All patients provided written informed consent. We used the STROBE cohort checklist when writing our report.[7]

A complete ophthalmological examination was performed for all subjects, including measurement of intraocular pressure, CDVA and slit-lamp biomicroscopy of the anterior and posterior segments. CDVA testing was performed with Snellen charts. Age, sex, systemic disease, systemic therapy, previous ophthalmic surgery, localisation, extension of retinal detachment and macular status were recorded preoperatively. Retinal data were carefully rechecked intraoperatively and were updated, where appropriate.

Inclusion criteria were all phakic or pseudophakic eyes with uncomplicated RRD. Exclusion criteria included phakic RRD cases in which a combined surgery (cataract surgery and vitrectomy) would be needed. Further exclusion criteria were history of ocular trauma, previously failed retinal procedures, concurrent proliferative diabetic retinopathy, retinal detachments through a macular hole, uveitis, topical or systemic corticosteroid therapy, and rheumatological and/or other immune-mediated systemic diseases, such as rheumatoid arthritis.

Patients presented for a follow-up visit 6 weeks, 3 months and 6 months after surgery.

Intraoperatively, patients were assigned to one of two groups. Eyes with tears, holes and lattice degeneration zones extending 180° or more were assigned to group 1 and treated with 360° ELR. Eyes with retinal breaks and retinal degeneration extending less than 180° were assigned to group 2 and treated with focal ELR.

Primary and secondary aims of the study

The primary and secondary aims of this study were centred on a comparison of the effects of 360° ELR (group 1) and focal ELR (group 2) on various parameters.

The primary aim of the study was to investigate the effect of laser retinopexy on pupillary diameter and the resulting pupillotonia of the affected, compared with the partner eyes, between groups 1 and 2. Pupil diameter difference (PDD), defined as the pupil diameter of the affected eye subtracted by the pupil diameter of the fellow eye, was devised as a more independent marker of pupillotonia.

Secondary outcomes were centred on the effect of both treatment modalities on CDVA, inflammatory effect on the macula (ie, CME and ERM), redetachment and, when applicable, the number of weeks until this occurred. We also evaluated whether the extent of retinal detachment had any effect on the decision to perform focal or 360° ELR and on the decision on which endotamponade was used, namely 2000cst or 5000cst SO or perfluoropropane gas (C_3F_8).

As described in previous publications, postoperative visual acuities of counting fingers, hand motion and light perception were converted to 6/450, 6/1200 and 6/6000 acuities, respectively.[8]

Finally, we performed a subgroup analysis of PDD outliers, namely, on the 20% of eyes that had the greatest increase in PDD after 6 weeks.

Surgical technique

Surgeries were performed under local anaesthesia with a retrobulbar block or under general anaesthesia, according to patient preferences.

After displacing the conjunctiva, three cannulas were inserted using a bevelled trocar into the inferotemporal, superotemporal and superonasal quadrants. A 23-gauge infusion cannula was placed at the inferotemporal sclerotomy site.

Central and peripheral vitrectomy was performed, and vitreous base shaving was performed in all patients with scleral depression. Retinal breaks were localised and marked with endodiathermy. Fluid/air exchange was then performed. Endolaser treatment was performed under air. In all cases, ELR was performed around the retinal breaks, holes and areas of lattice degeneration. In eyes from group 1 additional 360° ELR was performed as three rows of medium-white burns anterior to the level of the vortex vein, towards and beyond the equator. All burns were distanced one burn width apart.

Pupillometry measurements

All pupillometry measurements were performed by the same team of blinded clinicians, and the same automated pupillometry system was used (Pentacam HR, Oculus, Germany). No ocular examination or pupillary dilatation was performed before the procedure and images were shot after five min of dark adaptation. Only high-quality images were included to minimise clinician-induced errors and all pupillary measurements were performed under the same environmental conditions.[9] Proprietary analysis software allowed the clinician to draw the pupil contour automatically on captured images, to ensure that measurements were taken under accurate and controlled lighting conditions. Images of both eyes were obtained and processed in real-time (30 images/s). Dark conditions were used to prevent reflections during the procedure. After the clinician fixed the pupil to the centre of the eye with the real-time image on the device's monitor, the system automatically recorded 50 images with the help of a rotating Scheimpflug camera within 2 s. Measurements with an image quality of 95% or more were considered appropriate for analysis.[10] Figure 1 illustrates how pupil diameter was assessed.

Statistical tests

All visual acuities were converted to the logarithm of the minimal angle of refraction (logMAR). We calculated the median, mean, SD and range of all values for the included eyes. Available variables were tested for normal distribution using the conjunction of a graphical quantile-quantile test and the Shapiro-Wilk test. For our primary outcomes, 95% CI for means or medians were calculated using a z-statistic of 1.96 for normally distributed data and using a two-sided bootstrap method for non-gaussian samples, as described elsewhere.[11]

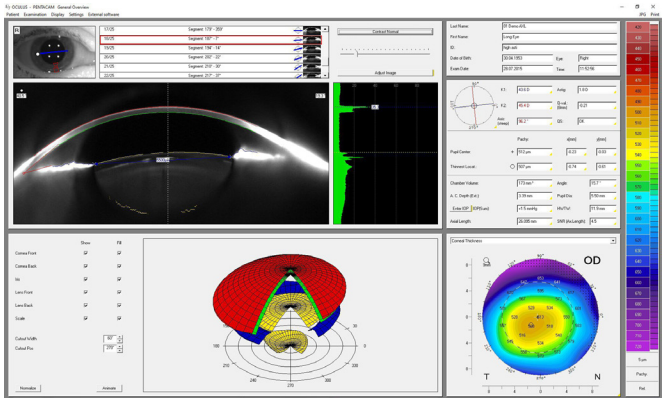

Figure 1 Pentacam pupil measurment illustrates the process of true pupil diameter measurement using a tomographic slice of the anterior segment.

Table 1 Baseline characteristics numerical variables

	360° laser group		Focal laser group		Group difference
Preoperative parameter	n	Mean±SD	n	Mean±SD	P value
Age (years)	42	60.64±13.93	30	59.3±8.97	0.6488
Axial length affected eye (mm)	24	25.19±1.29	20	25.27±1.26	0.8411
Axial length fellow eye (mm)	24	25.18±1.31	20	25.06±1.27	0.7623
CDVA affected eye (logMAR)	42	1.18±0.85	30	0.71±0.71	0.0085
CDVA fellow eye (logMAR)	42	0.08±0.13	30	0.06±0.1	0.2501
Detached quadrants	42	2.29±0.66	30	1.87±0.5	0.0033
Pupil diameter affected eye (mm)	42	3.24±0.84	30	2.94±0.76	0.1303
Pupil diameter fellow eye (mm)	42	2.99±0.75	30	2.81±0.76	0.3443
Pupil diameter difference (mm)	42	0.26±0.56	30	0.13±0.39	0.0906

CDVA, corrected distance visual acuity; logMAR, logarithm of the minimum angle of resolution.

Differences between groups were assessed using the paired or independent t-test to assess for significant differences between variables sampled from a Gaussian distribution. Non-normally distributed variables were analysed using the Wilcoxon signed-rank test for matched pairs (before and after) and the Mann-Whitney U test for independent samples. Comparisons between categorical variables were performed using Fisher's exact test, chi-square test of homogeneity with or without Yates correction or the McNemar χ^2 test where appropriate. To analyse the effect of possibly confounding factors, such as the lens status or endotamponade used, we used linear mixed models.

The threshold for statistical significance was set at $p<0.05$. When applicable, an additional α' was determined using Bonferroni correction for multiple comparisons to all simultaneous tests, including correlated ones. All statistical analyses were performed using the programming language Python V.3.7 run on PycharmEdu 2019 (JetBrains, Prague, Czech Republic) for Microsoft Windows (Microsoft, Albuquerque, New Mexico, USA).

RESULTS

A comparison of our baseline population of 72 eyes, of which 42 were in group 1 and 30 in group 2, is shown in tables 1 and 2. Table 1 contains all numerical variables, whereas table 2 contains categorical variables. No patient was lost to follow-up. A possible adjustment of α using Bonferroni correction of the baseline comparisons would yield an α' of 0.002777.[12 13] This adjusted α' would yield no statistical difference between both groups preoperatively.

Primary outcomes

Effect of surgery on pupillary diameter (PDD)

Postoperative PDD, as observed at 6 weeks, was significantly greater than preoperative averages in both groups 1 and 2. It increased by a mean of 1±1.11 mm (95% CI 0.98 to 1.54) in group 1 and by 0.5±0.78 mm (95% CI 0.35 to 0.85) in group 2. This initial increase in PDD receded over time, but remained statistically significant in both groups, even at 6 months. The trajectory of the mean PDD across all follow-ups is shown in figure 2. PDD decreased considerably in both groups ($p_1=0.0002$ and $p_2<0.0001$) from 6 weeks after surgery to 3 months after surgery, with no statistically significant difference in the decrease being noted between both groups. PDD also decreased in both groups from 3 months to 6 months, with this decrease being significant only in group 2 ($p_1=0.1899$ and $p_2=0.0030$). At 6 months, PDD was still significantly greater than at baseline in both groups with PDD having increased by a mean of 0.49±1.06 mm (95% CI 0.17 to 0.81) in group 1 and by 0.27±0.65 mm (95% CI 0.01 to 0.5) in group 2. The changes in outcomes from baseline to 6 weeks after surgery are shown in table 3. Table 4 shows outcomes at 6 months postoperatively.

Subgroup comparisons

A subgroup comparison of both groups by endotamponade used and lens status can be seen in table 5. Independent t-test of the subgroups showed a significant impact of the lens status for eyes that were in group 1. Phakic eyes had a nearly twice as large PDD change at 6 weeks compared with pseudophakic eyes (p=0.00298). A type III fixed effect mixed model analysis confirmed the significance of that finding (p=0.03714. No significant effect of lens status on PDD change at 6 weeks was found for in the focal laser group (p=0.92559). Similarly no significant impact of endotamponade on PDD change at 6 weeks could be found for either study groups (p=0.54154; p=0.67355). The full subgroup analyses of postoperative changes by week 6 as

Table 2 Baseline characteristics categorical variables

Preoperative parameter	n	Category: count (% of 360° laser group)	Category: count (% 360° laser group)	n	Category: count (% of focal laser group)	Category: count (% focal laser group)	P value
Gender	42	Male: 25 (59.5)	Female : 17 (40.5)	30	Male : 17 (56.7)	Female : 13 (43.3)	1
Diabetes	42	No diabetes: 40 (95.2)	Type II Diabetes: 2 (4.8)	30	No Diabetes : 30 (100.0)		0.5070
Arterial hypertension	42	Yes: 24 (57.1)	No: 18 (42.9)	30	Yes: 8 (26.7)	No: 22 (73.3)	0.0201
Coronary artery disease	42	Yes: 9 (21.4)	No: 33 (78.6)	30	Yes: 2 (6.7)	No: 28 (93.3)	0.1069
Amblyopia of affected eye	42	Yes: 1 (2.4)	No: 41 (97.6)	30	Yes: 30 (100.0)		1
Affected side	42	Right: 16 (38.1)	Left: 26 (61.9)	30	Right : 21 (70.0)	Left: 9 (30.0)	0.0151
Lens status	42	Pseudophakic: 24 (57.1)	Phakic: 18 (42.9)	30	Pseudophaki: 11 (36.7)	Phakic: 19 (63.3)	0.1403
Macula attached	42	Yes: 10 (23.8)	No: 32 (76.2)	30	Yes: 13 (43.3)	No: 17 (56.7)	0.1348

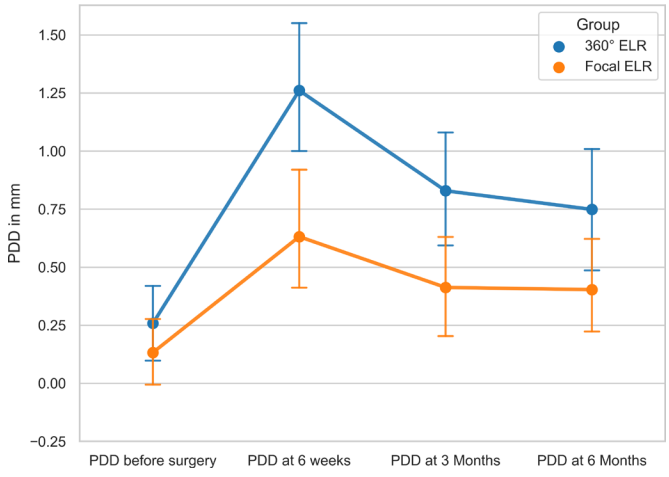

Figure 2 Pupil diameter difference (PDD) before and after surgery. Figure 2 shows the PDD before surgery and at the three follow-ups. At each time-point, the dot denotes the mean in either group while the bars denote the 95% CI of the population mean.

split by endotamponade and lens status are to be found as online supplemental appendix tables A and B.

Redetachment rate

There were seven redetachments across our study population, yielding a redetachment rate of 9.7% (95% CI 3% to 17%). With a redetachment rate of 9.5% (n=4) in group 1 and 10% (n=3) in group 2 there was no statistically significant difference between both groups.

Secondary outcomes

In 76.2% (n=32) of eyes assigned to group 1, there was macular involvement of retinal detachment compared with 56.7% (n=17) in group 2. This difference was not statistically significant (p=0.1348). The number of detached quadrants was significantly greater in the 360° laser group (2.29±0.66) than in the focal laser group (1.87±0.5; p=0.0033). Both groups did not differ statistically significantly with respect to their preoperative lens status, with 57.1% being pseudophakic in group 1 and 36.7% being pseudophakic in group two (p=0.14030); all other eyes were phakic.

Effect of surgery on CDVA

Both groups differed significantly (before Bonferroni correction) with respect to the initial CDVA of the eyes affected by retinal detachment (p=0.00859). Eyes assigned to group 1 had markedly more visual impairment before vitrectomy than the eyes assigned to group 2. The CDVA of the eyes in both groups improved significantly after 6 weeks. Figure 3 shows the improvement of CDVA across all follow-ups.

Rate of postoperative ME and ERM

With relatively few instances of ME and ERM across both groups, we saw a higher rate of ERM and oedema in group 1 at all three follow-ups, without the difference between both groups reaching statistical significance at any follow-up. Figure 4 shows the proportion of eyes with ME by group.

A longitudinal analysis of the presence of ME only showed a significant increase from 0 to 8 eyes with ME (19%) in group 1 at 6 weeks (p=0.0054). In group 1, the ERM rate increased significantly from 0 preoperatively to 7 (17.1%) at 3 months (p=0.0054) and 9 (22.5%) at 6 months after surgery (p=0.0009).

In group 2, neither ME nor ERM rates changed significantly from baseline.

Surgeons choice of endotamponade

When comparing surgeons' choice of endotamponade at primary surgery, we observed that eyes in group 1 received SO (n=21) and C_3F_8(n=21) with equal frequency. Eyes in group 2 received C_3F_8in 24 cases (80%) and SO in 6 cases (20%). The difference between both groups was found to be statistically significant (p=0.019006).

All seven eyes with redetachment received SO as an endotamponade during their secondary surgery.

Pupil diameter outliers at 6 weeks

The subgroup analysis of PDD outliers at 6 weeks (the upper quintile) showed no significant preoperative differences between the entire study population and the designated subgroup. However, 13 out of 15 eyes were from group 1, which is a

Table 3 Primary and secondary outcome changes at 6 weeks

	360° laser group			Group difference	Focal laser group		
Difference preoperative to 6 weeks postoperative	n	Mean±SD (95% CI)	Pre–post difference (p value)	P value	n	Mean±SD (95% CI)	Pre–post difference (p value)
Pupil diameter difference (mm)	42	1±1.11 (0.66 to 1.34)	<0.0001	0.0383	30	0.5±0.78 (0.17 to 0.73)	<0.0001
Pupil diameter affected eye (mm)	42	0.96±1.06 (0.64 to 1.28)	<0.0001	0.1830	30	0.65±0.81 (0.34 to 0.92)	0.0002
Pupil diameter fellow eye (mm)	42	−0.04±0.45 (−0.18 to 0.1)	0.5491	0.1013	30	0.15±0.62 (−0.05 to 0.41)	0.2137
CDVA affected eye (lines of improvement)	42	6.7±7.3 (4.4 to 8.9)	<0.0001	0.0411	30	3.4±6.2 (1.2 to 5.7)	<0.0001
CDVA fellow eye (lines of improvement)	42	0.2±0.8 (−0.1 to 0.4)	0.1755	0.4665	30	0.1±0.9 (−0.3 to 0.4)	0.0004
Macular oedema	42	19.0% (7% to 31%)*	0.0054	0.1776	30	6.7% (0% to 16%)*	0.4915
Macular pucker	42	11.9% (0.02% to 21.7%)*	0.0551	1	30	10.0% (0% to 20.7%)*	0.2373

Pupil diameter difference is the pupil diameter of the eye affected by the retinal detachment subtracted by the pupil diameter of the fellow eye.
*Denotes the proportion of eyes with the presence of macular pathology (oedema or pucker) with the 95% CI of this proportion.
CDVA, corrected distance visual acuity.

Table 4 Primary and secondary outcomes at 6 months

Parameter at 6 months	360° laser group n	Mean±SD (95% CI)	Pre–post difference (p value)	Group difference P value	Focal laser group n	Mean±SD (95% CI)	Pre-post difference (p value)
Pupil diameter difference (mm)	42	0.75±0.86 (0.49 to 1.01)	0.0017	0.0212	30	0.4±0.54 (0.21 to 0.6)	0.0001
Pupil diameter affected eye (mm)	42	3.77±0.97 (3.48 to 4.07)	0.0017	0.0396	30	3.32±0.76 (3.04 to 3.6)	0.0069
Pupil diameter fellow eye (mm)	42	3.02±0.84 (2.76 to 3.28)	0.6622	0.3446	30	2.92±0.84 (2.61 to 3.22)	0.2926
CDVA affected eye (lines of improvement)	41	0.25±2.16 (–0.42 to 0.92)	0.0001	0.1097	29	–0.06±2.5 (–0.99 to 0.87)	0.006433869
CDVA fellow eye (lines of improvement)	41	0.02±0.15 (–0.02 to 0.07)	0.3404	0.2084	29	0.05±0.06 (0.01 to 0.1)	0.208959266
Macular oedema	41	12.2% (4.1% to 26.2%)*	0.1569	0.3893	29	3.4% (0.1% to 17.8%)*	0.4915
Macular pucker	40	22.5% (10.8% to 38.5%)*	0.0009	0.2183	29	10% (2.2% to 27.4%)*	0.1124

Pupil diameter difference is the pupil diameter of the eye affected by the retinal detachment subtracted by the pupil diameter of the fellow eye.
*Denotes the proportion of eyes with the presence of macular pathology (oedema or pucker) with the 95% CI of this proportion.
CDVA, corrected distance visual acuity.

statistically significant overrepresentation of eyes from group 1 (p=0.0435). These eyes had an average pupil diameter of 5.24 mm at 6 months and a PDD of 1.41±0.92 at the same follow-up.

DISCUSSION

Dilated pupils and pupillotonia are complications that have been reported after treatment with laser retinopexy. These conditions can cause photophobia and photopsia due to the excessive amount of light entering the eye, which may increase ocular aberration and cause visual symptoms. It has been hypothesised that laser treatment leads to pupillotonia by damaging the short ciliary fibres.[5 6] In a study with 40 eyes with diabetic retinopathy Yilmaz *et al*[14] showed that treatment with panretinal laser coagulation may significantly increase pupil size. Tonic pupil has also been observed also after vitrectomy with endolaser in retinal detachment repair.[5]

In our study, the pupil diameter increased significantly in both groups postoperatively. Over time, this difference decreased, but remained significantly higher compared with the preoperative PDD, especially in the 360° laser coagulation group. The difference in pupil diameter between the affected and non-affected eye was higher in the 360° laser group than in the focal laser group during the last follow-up examination, demonstrating a stronger pupillotonia effect from the 360° laser coagulation group than from the localised treatment group. However, in both groups, the amount of pupil dilation decreased during follow-up in most patients. One unexpected finding is that the wide and statistically significant divergence of pupil diameter change at 6 weeks between phakic and pseudophakic eyes. Previous publications had mentioned the miotic effect of phacoemulsification surgery.[15 16] In our population, there was no significant difference between preoperative pupil diameter of the affected eye when comparing phakic and pseudophakic eyes (see online supplemental appendix C). We theorise, that an underlying pupil dilatator insufficiency caused by phacoemulsification surgery, blunts the effect of the ciliary fibre damage induced by extensive ELR.

To our knowledge, this is the first prospective study to measure the effect of pupillotonia and to directly compare the pupil effect of 360° ELR with ELR for the treatment of uncomplicated retinal detachment.

Similar to our study, Bilgin *et al* reported no differences in single-surgery anatomic success and functional outcomes between circumferential and localised laser retinopexy in 50 patients with uncomplicated retinal detachment who underwent PPV.[17] More recently, Loiudice *et al*[18] investigated the efficacy of intraoperative localised and 360° ELR in cases of RRD and PVR treated with PPV and air tamponade in a prospective, randomised, comparative study. Their anatomical and functional success between 360° laser application and localised laser was comparable to ours.

Retinal detachment with undetected retinal breaks is often associated with poor anatomical success. Zhou *et al*[19] reported that, in cases of SO-filled RRDs with undetected retinal breaks, a higher primary success rate existed when compared with localised laser photocoagulation.

Table 5 Subgroup comparisons by endotamponade and lens status

Difference preop to 6 weeks postop	360° laser group			Group difference	Focal laser group		
Pupil diameter difference (mm)	n	Mean±SD (95% CI)	Pre–post difference (p value)	P value	n	Mean±SD (95% CI)	Pre–post difference (p value)
Silicone oil endotamponade	21	1.11±1.25	0.0099	0.3160	6	0.57±0.38	0.1892
		(0.63 to 1.65)				(0.3 to 0.9)	
Gas endotamponade	21	0.9±1	0.2105	0.0937	24	0.42±0.86	0.1059
		(0.53 to 1.3)				(0.13 to 0.73)	
Phakic	18	1.58±1.27	0.1308	0.0937	19	0.44±0.96	0.0215
		(1.01 to 2.07)				(0.03 to 0.9)	
Pseudophakic	24	0.57±0.78	0.0210	0.3160	11	0.47±0.37	0.7280
		(0.27 to 0.88)				(0.28 to 0.67)	

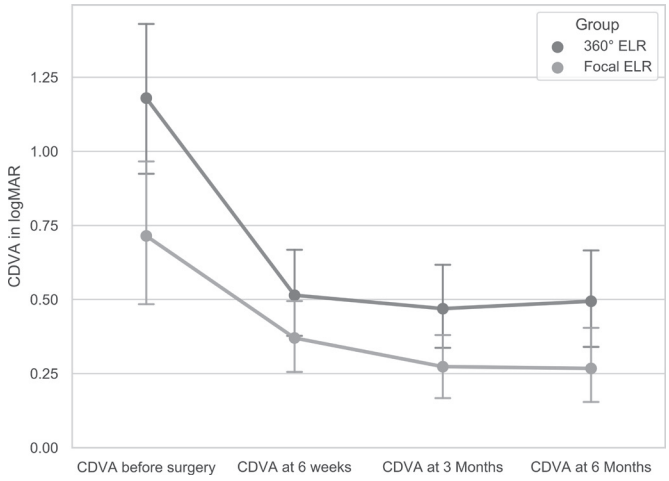

Figure 3 CDVA of affected eye before and after surgery. Figure 3 shows the average CDVA before surgery and at the three follow-ups. At each time point, the dot denotes the mean in either group awhile the bars denote 95% CI of the population mean. CDVA, corrected distance visual acuity; ELR, endolaser retinopexy.

Localised ELR administration has the advantage of being less invasive and reducing operative time compared with 360° laser application. Furthermore, broad intraoperative laser application is considered a risk factor for PVR and may be complicated by choroidal effusion, ERM formation, haemorrhage and possibly with the formation of new retinal breaks.[20 21] In our study, we could only find a non-significant tendency of an inflammatory effect of laser on the macula, as evidenced by ME and ERM rates. Due to the low incidence of these outcomes, we deem our study underpowered to evaluate that question.

One limitation of the study one has to bear in mind, is its observational design. Since eyes in group 1 (360° ELR) had more extensive retinal breaks and more quadrants detached than those assigned to group 2 (focal ELR), it remains unclear whether focal ELR would have equal anatomic success with comparable retinal detachments. Only a randomised study is adept to answer this question. A further shortcoming of our study is the lack of corroboration of the relevance of pupillotony with preoperative and postoperative visual function questionnaires. Nonetheless, we expect the observations of our primary outcome to stand the test of time. Moreover it being an index study on pupil diameter changes, the majority of our findings remain valid regardless of problems with secondary outcomes.

The conclusions of our prospective study are that pupillotonia after laser retinopexy is most pronounced at 6 weeks after surgery but slowly recedes without reaching baseline by 6 months. There is a statistically significant difference between the increase in pupil diameter and whether circumferential ELR or focal ELR was employed, with 360° ELR causing more disturbance of pupil width and function. There was no difference in the redetachment rates between the two treatment groups. Circumferential laser retinopexy did not lead to more inflammatory drive in the macula, as evidenced by non-significant between-group ME and ERM rates. One interesting finding of the study was that in cases with more detached retinal quadrants and lower initial CDVA, circumferential laser retinopexy was the treatment of choice by the operating surgeon.

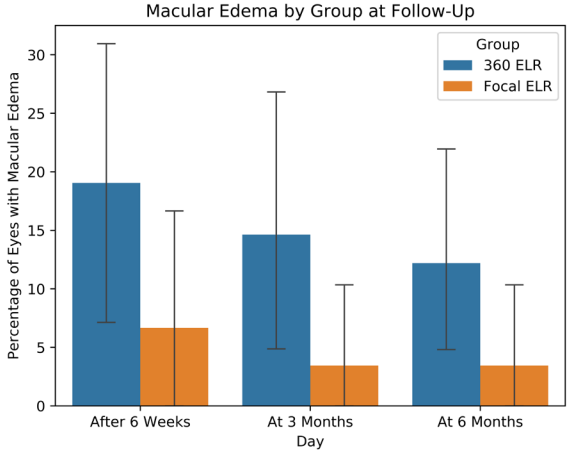

Figure 4 Macular oedema (ME) denotes bar plots of the proportion of eyes with ME in each group, respectively, with the corresponding 95% CI estimate. The difference between both groups is at no point statistically significant. Within group 1, the increase from preoperatively to week 6 is statistically significant. ELR, endolaser retinopexy.

Contributors CS initiated the collaborative project, designed the surgical treatment protocol and data collection tools, executed and monitored data collection for the whole trial, wrote the statistical analysis plan. He is guarantor. DT cleaned the data, wrote the statistical analysis plan, performed the statistical analysis of the data, and drafted and revised the manuscript and served as corresponding author. The authors CS and DT contributed equally to the manuscript and would each like to share first authorship. K-UB-S monitored data collection for the whole trial, and revised the draft manuscript. TK designed the data collection tools, drafted the methods section and revised the manuscript. MS designed the statistical analysis plan and analysed the data and revised the manuscript. SD designed the data collection tools, implemented the trial at his institution, executed and monitored data collection at his institution for the whole trial and drafted the discussion. All authors except DT were also vitreoretinal surgeons adhering to the operative treatment protocol.

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