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Perfluorocarbon liquid vitreous delamination and wide-angle viewing system in the management of complicated diabetic retinal detachment

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PURPOSE. *The authors used perfluorocarbon liquid (PFCL) and a wide-angle viewing system (WAVS) to evaluate their efficacy on tractional and combined tractional/rhegmatogenous retinal detachment (RD) secondary to proliferative diabetic retinopathy (PDR).*

METHODS. *In a prospective, noncomparative, interventional study, 76 consecutive cases of severe PDR with tractional and combined tractional/rhegmatogenous RD were submitted to vitrectomy en bloc excision technique using a WAVS and delamination with PFCL between July 1999 and December 2003. None of the patients had had previous retinal photocoagulation treatment. Preoperative characteristics, intraoperative findings, and procedures as well as postoperative results were recorded. Main outcome measures included visual acuity (VA) and rates of retinal reattachment and complications.*

RESULTS. *After 1 to 4 years of follow-up (mean 34.3 months), the number of patients changed from 3 (3.95%) to 11 patients (14.47%) in the ≥20/40 VA range, from 12 (15.79%) to 7 (9.21%) in the 20/50 to 20/200 group, and from 61 (80.26%) to 58 (76.31%) in the ≤20/400 group, preoperatively and postoperatively, respectively. The mean final VA improved from 1.2 logMAR before surgery to 0.89 after vitrectomy (p=0.001). This modified technique resulted in less bleeding during surgery, a better identification of intraocular structures, faster retinal reattachment, subretinal fluid reabsorption, and easier dissection of fibrovascular membranes, among other benefits.*

CONCLUSIONS. *PFCL and WAVS appear to reduce intraoperative complication rates in the management of complicated cases of tractional and combined tractional/rhegmatogenous RD secondary to PDR. Retinal reattachment and functional vision rates improved after this technique. (Eur J Ophthalmol 2009, 19: 452-9)*

KEY WORDS. *Perfluorocarbon liquid, Proliferative diabetic retinopathy, Retinal detachment, Vitreoretinal surgery, Wide angle viewing system*

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INTRODUCTION

Perfluorocarbon liquid (PFCL) and wide-angle viewing systems (WAVS) represent major advances in vitreoretinal surgery. The former is an effective tamponading agent having many useful applications (1-6), with its high specific gravity, surface tension, transparency, and low viscosity making PFCL a very effective surgical tool.

Vitreous surgery has become the standard treatment for blinding complications of fibrovascular tissue growth in patients with proliferative diabetic retinopathy (PDR) (7-9). The en bloc excision of fibrovascular tissue with attached posterior hyaloid has been previously described (10, 11), with this technique allowing removal of the sources of tangential traction that produce tractional retinal detachment, as well as the fibrovascular membranes that gener-

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ate postoperative bleeding. However, one of the main disadvantages of this technique is an increased risk of retinal breaks due to dissection of the fibrovascular tissue adhered to the retina, and also from potential traction at the vitreous base exerted by the retained posterior hyaloid. Moreover, this technique may be difficult to carry out in the fundus periphery where viewing is more difficult and the retina is thinner and rather ischemic.

Since its original description, many articles have suggested modifications to the technique, thereby easing the manipulation of fibrovascular tissue and making membrane dissection less traumatic, resulting in reduced postoperative morbidity (12-15).

Tractional and combined tractional-rhegmatogenous retinal detachments (RD) represent the most feared and surgically challenging conditions associated with PDR. Some of the most common operative complications in these cases are intraoperative vitreous hemorrhages and iatrogenic retinal holes (12, 16-17).

The effectiveness of PFCL and WAVS has been widely demonstrated in the management of various vitreoretinal conditions in addition to the ones described above (1-5, 18-21).

In the present study, we used a modified en bloc technique using PFCL and a WAVS for the management of 76 cases of tractional and combined tractional-rhegmatogenous RD secondary to severe PDR.

METHODS

An en bloc excision technique using a wide-angle observation system and delamination with PFCL was performed in 76 consecutive cases of severe PDR with pure tractional or combined tractional-rhegmatogenous RD between July 1999 and December 2003. All eyes had extensive fibrovascular membranes resulting in tractional elevation of the retina.

Participants

Patients with diabetes and proliferative vitreous retinopathy with tractional and/or tractional/rhegmatogenous RD as demonstrated by complete eye examination or echography were included in the study. However, patients with previous vitrectomies, or with corneal or anterior segment pathology at the moment of diagnosis, were excluded. Visual acuity was worse than 20/30, but better than hand motion in the affected eye for patients aged 21 or over. A full and detailed explanation of the surgical technique and its risks and benefits were given to all patients, with written consent being obtained.

The following patient data were recorded preoperatively: patient age, sex, type of diabetes, previous ocular history (including previous intraocular surgery or photocoagulation), visual acuity (VA), slit-lamp biomicroscopy, and indirect ophthalmoscopy. Intraoperative data collected included scleral buckling, gas tamponade, endophoto- coagulation, and combined surgery (vitrectomy and cataract surgery). Patients were scheduled to be followed at day 1, day 3, 2 weeks, 1 month, 3 months, once a year, and every subsequent year after surgery. Postoperative data included final VA, development of cataracts, recurrent RD, recurrent vitreous hemorrhage, and the need for further surgical procedure.

Procedure

All eyes underwent a conventional vitrectomy using a three-port 20-gauge pars plana technique with retrobulbar anesthesia and facial nerve block. All surgeries were performed by one of the authors (J.D.L.). Removal of the central vitreous cavity was performed first. Subsequently, the posterior hyaloid membrane was lifted and a small amount of PFCL was injected between the cortical vitreous and the retina, following the creation of a 1 to 4 mm diameter hole in the detached cortex by means of a microvitreoretinal blade or suction cutter (Fig. 1). When subhyaloid hemorrhage was present, blood was extracted using a Charles cannula. If the cortical vitreous was attached, a pick was inserted under the fibrotic glial ring in order to be able to separate the vitreous from the optic disc easily. In the eyes of patients with PDR, Weiss ring is usually dense and readily identified. Also, glial ring adhesion is normally relatively strong because of optic disc neovascularization and associated proliferative tissue; retinal breaks or uncontrollable hemorrhage do not usually occur.

The speed and volume of injection of the heavy liquid were controlled by the surgeon. Injection was done in a meticulous manner in order to decrease the chances of producing iatrogenic retinal holes and also to control the level of PFCL, thereby avoiding retinal tears or entering the subretinal space. At this point of the vitrectomy, the PFCL anatomically stabilized the macula, improved the visibility of residual membranes, and provided posterior counter-traction for further membrane peeling at the midperiphery and at other anterior locations (Fig. 2). This was possible to accomplish simultaneously with the delamination process, due to the extensive view of the retina provided by the wide-angle observation system (WAVS).

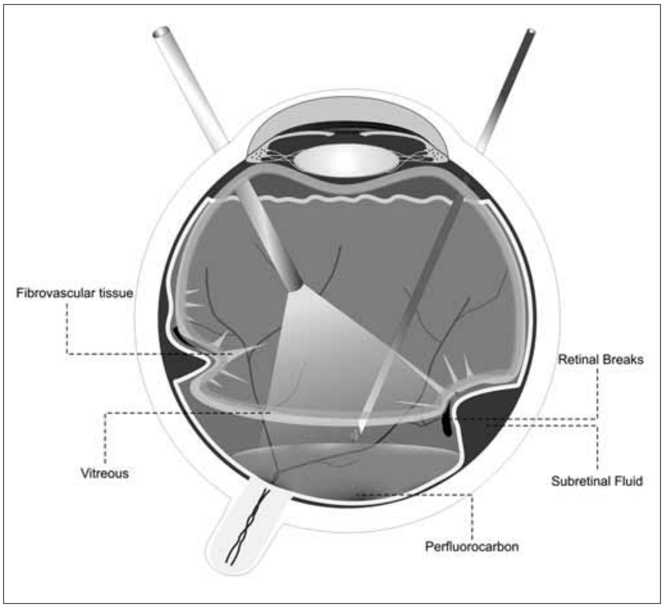

Fig. 1 - *Perfluorocarbon liquid is injected between the cortical vitreous and the retina following the creation of a 1 to 4 mm diameter hole in the detached cortex.*

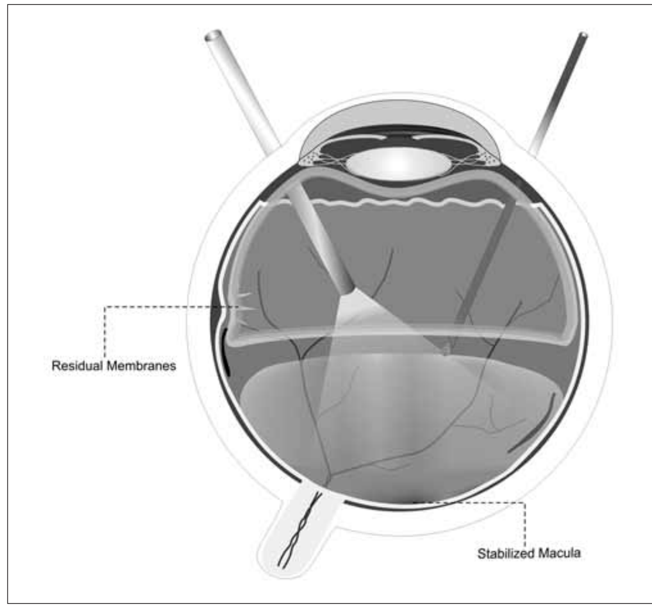

Fig. 2 - *Perfluorocarbon liquid anatomically stabilizes the macula and provides posterior countertraction for further membrane peeling in the midperiphery and anterior locations.*

When complete peeling of a neovascular membrane was difficult to achieve using bimanual techniques, PFCL was injected until the posterior hyaloid started to exert traction on the retina, and then it was liberated using the suction cutter until traction was eliminated. Thus, the PFCL acted as a third hand during membrane dissection, while simultaneously flattening the surrounding retina. PFCL induced a complete egress of subretinal fluid through the retinal tears (Fig. 3). When this was not the case, subretinal fluid drainage was performed through preexisting retinal holes. At this point, with the eye filled of PFCL, endolaser photocoagulation is possible (Fig. 4).

When intraoperative blood loss occurred, PFCL helped to tamponade the bleeding without the need to raise the infusion bottle in an attempt to increase the intraocular pressure (IOP). PFCL also assisted in such cases by dislocating the posterior hemorrhage to the periphery of the PFCL bubble, which improved the view of the area surrounding the bleeding and facilitated hemorrhage removal from the edge of the bubble.

With this modified technique, the posterior hyaloid membrane, which includes the proliferative tissues, was lifted and peeled away from the posterior to the peripheral retina until total separation of the posterior hyaloid membrane occurred. Vitrectomy was then completed using the suction cutter, by removing the epiretinal membranes and

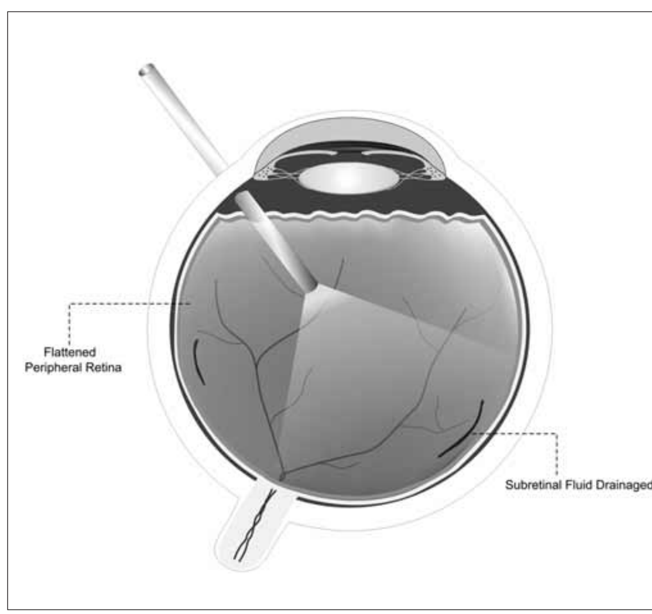

Fig. 3 - *Total separation of the posterior hyaloid membrane is achieved. Vitrectomy is then completed using the suction cutter.*

the posterior vitreous cortex (Fig. 3). The use of a WAVS allowed the surgeon to trim the vitreous base without scleral depression.

All the PFCL was aspirated after carrying out further mea-

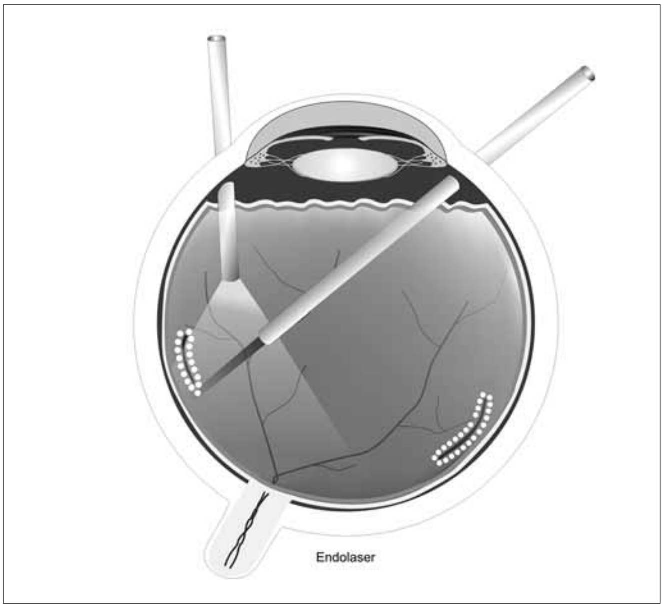

Fig. 4 - *With the eye filled with perfluorocarbon liquid, endolaser photocoagulation is possible.*

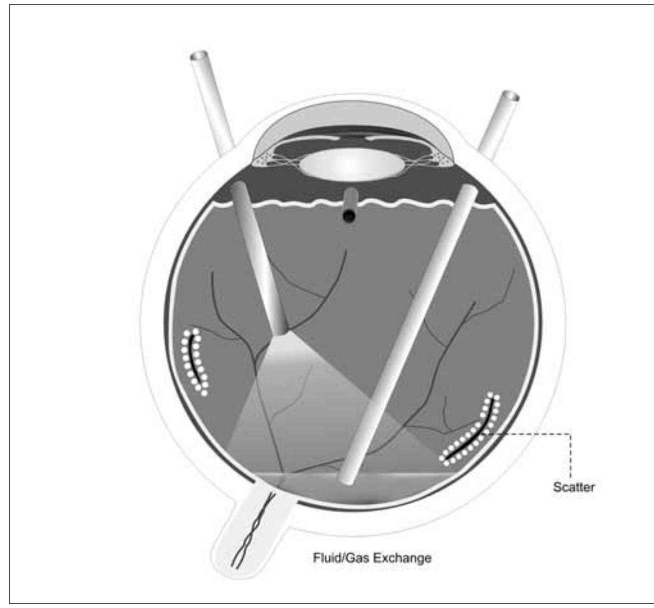

Fig. 5 - *Perfluorocarbon liquid is aspirated after further measures such as fluid/gas exchange and focal or scattered endophotocoagulation is performed in order to stabilize the posterior segment.*

sures to stabilize the posterior segment, such as fluid/gas exchange and focal or scattered endophotocoagulation (Fig. 5). Injection of gas (SF_6 or C_3F_8) or silicone oil was used at the end of each procedure in all cases.

Statistical Analysis

All visual acuities were converted to decimal equivalents and then to a logarithm of the minimum angle of resolution (logMAR) scale before being averaged. Conversion from counting fingers VA to 20/2000 with a decimal equivalent of 1.8 and from hand motion to 20/20,000 with a decimal equivalent of 3 was performed, as suggested by Holladay (22).
Linear regression analysis was used to compare the preoperative VA with the final VA.

RESULTS

We studied 76 eyes of 76 patients with severe proliferative vitreoretinopathy (PVR). The patients' demographic characteristics are shown in Table I. The mean age of patients was 58.7 years (range, 34–76), with the female/male ratio being 1.7. The number of right and left eyes operated on was similar. Insulin-dependent diabetes mellitus (IDDM) was more prevalent than non-insulin-dependent diabetes mellitus (NIDDM) among patients, with an IDDM/NIDDM ratio of 2.3. Most eyes did not have any previous ocular history, and interestingly, none of them had received panretinal photocoagulation treatment. A history of cataract surgery was present in 21% of patients, and chronic open-angle and neovascular glaucoma were present in 5% and 7.9% of patients, respectively, before the surgery was performed.
Preoperative findings are listed in Table II. All eyes showed RD, either pure tractional or combined tractional-rhegmatogenous, with 71 (93.4%) eyes within the first group and 5 eyes (6.6%) with combined RD. The mean best-corrected VA was logMAR 2.05 and 1.72, respectively. In all cases there was some degree of macular involvement. Vitreous hemorrhage was detected in 64.5% of patients, while iris neovascularization was found in only 7.9% of them. Cataracts were present in 22.4% of patients, 19.7% were pseudophakic, and 1.3% were aphakic.
Different surgical approaches were needed in order to achieve success, as seen in Table III. In approximately a quarter of patients, a combined cataract-vitrectomy procedure was carried out. In a small number of patients, scleral buckles were implanted (6.6%). Indications for

scleral buckle procedure included pseudophakic and aphakic status at the moment of surgery. A tamponading procedure was performed on all eyes, with C_3F_8 tamponade being the most used substance (72.4%), followed by silicone oil and SF_6. Indications for internal tamponade with silicone oil were the following: multiple holes in the inferior peripheral retina, more than one disc diameter retinal holes in equatorial or posterior retinal zone (usually iatrogenics), patients with only one functional eye, or the presence of PVR.

Pre- and postoperative logMAR VAs are shown in Table IV. The mean best-corrected preoperative VA was 1.85 and after surgery the best-corrected VA was 1.4. Most patients were in the <0.05 VA group, before and after surgery. However, there was a tendency to acquire VA postoperatively in all groups.

Postoperative complications included cataract formation, postoperative vitreous hemorrhage, and development of PVR with retinal redetachment. No endophthalmitis or retained subretinal PFCL were observed in any of the cases. As shown in Table V, of these patients, a total of 25 (32.9%) needed further surgical procedures, mainly concerning cataract extractions (22.4%), with the remaining reoperated eyes either having developed RD with PVR (5.3%) or vitreous hemorrhage (5.3%).

TABLE I - DEMOGRAPHIC STUDIES

Characteristics	No. (%) of eyes or mean (range)
Age, y	58.7 (34–76)
Sex	
Male	48 (63.2)
Female	28 (36.8)
Eye	
R	35 (46)
L	41 (53.9)
Diabetes	
Insulin-dependent	23 (30.3)
Non-insulin-dependent	53 (69.7)
Past ocular history	
Chronic open angle glaucoma	4 (5.3)
Neovascular glaucoma	6 (7.9)
Cataract surgery	16 (21)
Panretinal photocoagulation	0 (0)

TABLE II - PREOPERATIVE EXAMINATION

Characteristics	No. (%) of eyes
Iris neovascularization	6 (7.9)
Lens	
Cataract	17 (22.4)
Pseudophakic	15 (19.7)
Aphakic	1 (1.3)
Retinal detachment (RD)	76 (100)
Tractional RD	71 (93.4)
Combined RD*	5 (6.6)

*Tractional/rhegmatogenous RD.

TABLE III - OPERATIVE PROCEDURES

Procedures	No. (%) of eyes
Scleral buckle	5 (6.6)
Tamponade	
C_3F_8	55 (72.4)
SF_6	9 (11.8)
Silicone oil	12 (15.8)
Retinal reattachment	69 (90.8)

Vitrectomy and cataract surgeries.

DISCUSSION

Several procedures have been described to improve the treatment of complex RD in PDR, including segmentation with membrane delamination (23), the en bloc technique (11), and modifications to this latter method (12).

TABLE IV - VISUAL ACUITY (VA)

Category	Preoperative VA (mean 1.85)	Postoperative VA (mean 1.4)
>0.5	3 (3.9)	11 (14.5)
0.4 to 0.1	12 (15.8)	7 (9.2)
<0.05	61 (80.3)	58 (76.3)

Values are n (%) of eyes.

TABLE V - REPEATED OPERATIONS

Causes	No. (%) of eyes
Retinal detachment with PVR	4 (5.3)
Vitreous hemorrhage	4 (5.3)
Cataract	17 (22.4)

PVR = proliferative vitreoretinopathy.

The safety and efficacy of PFCL have been widely reported in the management of complex RD secondary to PDR (24-27) as a valuable adjuvant in conventional vitrectomy surgery and even in the use of the newest transconjunctival 25-gauge system, as reported by Quiroz-Mercado and coworkers (28).

The blinding sequelae of PDR, namely, RD and vitreous hemorrhage, result either from contraction of fibrovascular epiretinal membranes (ERMs) or avulsion of the edges of the membranes during posterior vitreous detachment (PVD), with retinal break formation or rupture of new vessels occurring.

The major strategies underlying the surgical treatment of PDR complications are first, reduction in the stimulus to vasoproliferation (by means of scatter endophotocoagulation of the ischemic retina) and second, removal of the post-basal vitreous cortex together with any fibrovascular tissue contained therein. Technical difficulties may arise, however, if the fibrovascular ERMs are excessively adherent or if the vitreous cortex remains extensively attached to the retina.

The forces leading to tractional RD are primarily transmitted along the posterior hyaloid in both the anterior and posterior directions, and also between the fibrovascular membrane and the vitreous base, with the other forces being transmitted in a tangential direction between separate epicenter proliferations.

Our technique describes the simplest way of delaminating the posterior hyaloid in these complex PDR cases. As already known, PFCL is a means of flattening the retina in a posterior to anterior direction. With our method, the delamination is under control owing to the wide angle viewing system, which enables the surgeon to control the whole retina and allows tensions to be reduced by cutting the fibrovascular membranes as soon as some traction has been identified when delaminating. Each epicenter of traction is effectively isolated without producing an iatrogenic retinal break, thus reducing the risk of retinal tear formation from peripheral dissection in the diabetic ischemic retinas. The modified en bloc dissection can then be completed because the tissue planes remained immobilized and mechanically separated by the PFCL.

Another advantage of this technique is that the intraoperative bullous elevation of the retina from the pre-existing mixed tractional and rhegmatogenous RD can be stabilized by introducing the PFCL, thereby fixing the posterior retina in position and providing the so-called third hand or counteraction. The difficulty in the surgical management of combined tractional-rhegmatogenous RD derives mainly from the presence of a bullous elevation of the retina, retinal mobility, adherences of the cortical vitreous, atrophic retinal changes in areas of vitreous traction, the location of the retinal breaks, and the close anatomic relationship with fibrovascular tissue. This degree of complexity is mainly responsible for the production of iatrogenic tears during vitrectomy.

PFCL is optically clear and immiscible with water and blood. This property is useful when viewing an actively bleeding eye. When intraoperative blood loss takes place, the PFCL helps to tamponade the flow of blood without the need of increasing the IOP. The PFCL also assists in these cases by dislocating the posterior hemorrhage to the periphery of the PFCL bubble, which clears the view of the area surrounding the bleeding and facilitates hemorrhage removal from the edge of the bubble. In addition, filling the eye with PFCL usually permits viewing and identification of potential areas of active bleeding, which may then be diathermized.

Although the costs of PFCL represent a major concern, the several benefits presented here make PFCL use a valid alternative in these complicated cases. Additionally, costs are lowered, since PFCL reduces the rates of intraoperative complications, thereby decreasing the number of reoperations needed. Furthermore, minimizing the number of reoperations enhances the patient's quality of life due to a less invasive therapy.

The prospective nature of this trial, the sample size of the study, and the visual results obtained in these cases demonstrate the effectiveness of the presented technique with the use of PFCL in severe cases of tractional/combined tractional-rhegmatogenous RD secondary to PDR. This is in agreement with previous studies that showed similar responses when using PFCL as an adjuvant for vitrectomy in severe PDR cases (26, 27). Although the visual outcomes are disappointing, the severity of the underlying disease and the initial VA seem to be the most important risk factors. A trend line calculated by using linear regression analysis showed better VA in patients who had better vision preoperatively than those who had a poor VA before the vitrectomy was performed.

However, variation in surgical technique, the criteria used for patient selection, the severity of the disease, and the differences in experience among surgeons are significant variables; thus direct comparisons between studies are difficult to make.

In this study, 100% of the patients had tractional RD before vitrectomy and did not present any laser photocoagulation treatment. The rate of successful retinal reattachment of 90.8% can be compared with that achieved in a previous series of diabetic traction RD managed with vitrectomy, which ranged from 69% to 97% (7, 12, 29). Our anatomic success rate may have been influenced by a reduced rate of iatrogenic retinal break formation, improved surgical instrumentation, and increased surgical experience with the en bloc excision technique since the original description (10, 30).

The rate of recurrent RD observed in this study (5.3%) was low compared with other studies (10–12%) (12, 30), which is explained in part as a result of the controls provided during delaminating, with the use of PFCL and WAVS making iatrogenic break less probable.

From a functional standpoint, a cautious approach to an en bloc excision may also be justified by the fact that our patients had not undergone laser photocoagulation prior to retinal surgery. In addition, most of these patients had poor metabolic control, which is common in Latin American diabetic patients.

In conclusion, PFCL delaminating assisted by WAVS for diabetic traction RD appears to reduce reoperation rates and increases the success of anatomic retinal reattachment compared with previously described methods. We propose the application of this technique as adjunct in the repair of complicated cases of diabetic tractional or combined tractional/rhegmatogenous RD.

The authors do not have any conflicts of interest or commercial involvement associated with this work.

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