Retinal Detachment Associated with Macular Hole in High Myopia

Using the Vitreous Anatomy to Optimize the Surgical Approach

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Purpose: To evaluate the efficacy of different surgical strategies on the postoperative outcomes of retinal detachments (RDs) associated with macular holes (MHs) in high myopia.

Design: Prospective, noncomparative case series.

Participants: The study included 120 phakic, highly myopic eyes (mean degree of myopia, -22.2 ± 4.80 diopters) with RDs and MHs that underwent surgical repair. The patients were divided into 2 groups. Group 1 consisted of 60 eyes with a posterior vitreous detachment (PVD). Mean preoperative visual acuity (VA) was 20/200±20/500. Group 2 consisted of 60 eyes with posterior vitreous schisis (PVS). The mean preoperative VA was 20/152±20/333. The minimum follow-up was 6 months.

Intervention: The surgical approach was chosen on the basis of the clinical characteristics. Twenty-five eyes of group 1 underwent pneumoretinopexy (group 1A), whereas 35 eyes of group 1 were repaired with vitrectomy (group 1B). Forty-nine eyes of group 2 underwent pars plana vitrectomy (group 2A), whereas 11 eyes of group 2 underwent scleral buckling of the macula (group 2B).

Main Outcome Measures: Anatomic attachment of the retina and VA.

Results: Retinal reattachment at 6 months was achieved in 23 of 25 (92%) eyes of group 1A, 31 of 35 (88.5%) eyes of group 1B, 45 of 49 (91.8%) eyes of group 2A, and 8 of 11 (72.7%) eyes of group 2B. A significant ($P<0.01$) improvement of postoperative VA with respect to the preoperative values was observed in all groups. The greatest percentage improvement in postoperative VA was observed in groups 1A and 1B eyes.

Conclusions: Different surgical approaches can be used to repair myopic RD associated with an MH. The choice between different surgical techniques may depend on vitreoretinal relationships, the extent of chorioretinal atrophic areas, and presence of posterior staphyloma. In our study, eyes with a PVD had significantly better visual outcomes than detachments in eyes with PVS. *Ophthalmology 2004;111:726–731 © 2004 by the American Academy of Ophthalmology.*

Retinal detachment (RD) with a macular hole (MH) occurs most commonly in highly myopic eyes.[1,2] The pathogenesis remains somewhat elusive. It was recently assumed, for instance, that vitreous traction was important only during the formation of the MH, whereas the RD arose as a consequence of scleral and chorioretinal changes.[1–3] In contrast to this hypothesis, clinical and surgical observations suggest that vitreous alterations also play a role in the genesis of RD.[4–7] It has been observed that vitreous changes are related, in most cases, to the degree of myopia and influence the features of RD.[8]

Several surgical methods have been described for the treatment of RD with MH in myopic eyes.[9–13] We felt that the vitreous pathology might logically provide guidance as to which surgical approach should be selected.

Our study aims to evaluate the influence of vitreous changes such as posterior vitreous detachment (PVD) or posterior vitreous schisis (PVS) on the clinical picture and, consequently, on the surgical approach and relative postoperative outcomes in RD with MH in eyes affected by high myopia.

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Materials and Methods

Patients

One hundred twenty phakic, highly myopic eyes of 120 patients (62 male and 58 female) with RD associated with MH were examined between February 1997 and November 1999. Patients were 42 to 68 years old (mean age, 53.6±6.42) and had myopia ranging from 18 to 26 negative diopters (D) (mean, −22.2±4.80). Inclusion criteria were myopia of more than −15 D; no history of eye surgery; an intraocular pressure of <21 mmHg on initial examination; and no history of ocular trauma, diabetes, or any other systemic disease.

The following preoperative examinations were performed in all patients:

- Indirect binocular ophthalmoscopy with a +20-D lens (Volk Optical Inc., Mentor, OH) and slit-lamp examination before and after surgery. A +90-D no-contact lens (Volk Optical) was used for the biomicroscopic examination.
- A-scan and B-scan ultrasonography using a 10-MHz probe (Humphrey Instruments, San Leandro, CA).
- Optical coherence tomography (OCT) (Humphrey Instruments).[14–17] The cross-sectional OCT images are the result of 100 A-scans obtained in 2.5 seconds. In our study, OCT examination was performed for each patient with a series of 6 horizontal and 6 vertical 4-mm-long scans over the posterior pole, after full pupillary dilation using tropicamide 1%.
- Best-corrected visual acuity (VA) was assessed by Snellen chart.

Patients were divided into 2 groups, based on the vitreous changes described in our previous report[8]: group 1, patients with RD and MH associated with PVD (60 eyes), and group 2, patients with RD and MH associated with PVS in the form of a wide posterior vitreous pocket or of ≥2 confluent posterior vitreous lacunae corresponding to and, in most cases, exceeding the area of the posterior staphyloma (PVS, 60 eyes).

The details of the vitreous anatomy of these patients are summarized in Table 1.

It is not easy to diagnose PVS versus PVD. In our study the vitreoretinal relationship and the vitreous modifications occurring on the posterior pole of myopic eyes have been evaluated by means of a series of examinations, including slit-lamp biomicroscopy, indirect ophthalmoscopy, A-scan and B-scan ultrasonography, and OCT. The diagnosis of PVS or PVD is obtained with the combined information of every examination, as each examination may add clinical details not often revealed by the others. Moreover, B-scan ultrasound and OCT often reveal details of the vitreoretinal relationship in an in vivo, dynamic manner during the examination itself, and the frozen and processed final images of these examinations do not always illustrate the same details.

The careful execution of B-scan ultrasonography and OCT was particularly useful in the differentiation of PVD and PVS. In our clinical and instrumental observations, PVS was diagnosed with slit-lamp examination when a uniform increase in density of the posterior vitreous cortex was detected and anatomically identified as the wall of the vitreous pocket. The lack of ascension/descension movements of the posterior vitreous cortex with eye movements during dynamic B-scan ultrasonography strongly points to the presence of PVS rather than PVD.[18] On ultrasound examination, PVD cases usually show wide, undulating aftermovements of the posterior vitreous cortex. In most cases of PVD, the vitreous cortex is displaced very anteriorly, and on horizontal, transverse B-scans it appears with a right-handed convexity following the curvature of the wall of the eye (Fig 1A, PVD eye). Posterior vitreous schisis does not have a unique ultrasound picture: multiple

Table 1. Clinical Characteristics of Patients with Retinal Detachment and Macular Hole

	Group 1: PVD Eyes	Group 2: PVS Eyes
Eyes (n)	60	60
Age	Range: 42–68 yrs (mean, 51.5)	Range: 42–68 yrs (mean, 52.3)
Gender	33 male, 27 female	29 male, 31 female
Myopia	18–26 negative diopters (mean, −21.5 ± 3.2)	18–26 negative diopters (mean, −22.7 ± 4.2)
Vitreoretinal findings	37/60 eyes: apparently complete PVD 8/60 eyes: posterior strands or veils 14/60 eyes: incomplete PVD 11/60 eyes: epimacular tissue Onset of the PVD: ≥3 days before diagnosis	56/60 eyes: thin transparent epiretinal membrane partially detached or extensively attached to the posterior retina Onset of the PVS: not defined
Surgery	Time elapsed from the diagnosis to the surgical treatment: 3 days on 60/60 eyes 25/60 eyes, pneumoretinopexy, group 1A 35/60 eyes, vitrectomy + gas (31 eyes) or SO (4 eyes), group 1B	Time elapsed from the diagnosis to the surgical treatment: 3 days on 60/60 eyes 49/60 eyes, vitrectomy + gas (25 eyes) or SO (24 eyes), group 2A 11/60 eyes, buckling of the macula, group 2B

PVD = posterior vitreous detachment; PVS = posterior vitreous schisis; SO = silicone oil.

layers of vitreous cortex are often observed in axial scans, with the most anterior of these layers often displaying a left-handed convexity (Fig 1A, PVS eyes 1 and 2). In our study, the echogenicity of the vitreous layers and of the subretinal fluid did not aid in differentiating PVS and PVD.

Optical coherence tomography may reveal the connections between the posterior vitreous cortex and the inner retinal surface. In cases in which a tight adhesion between the posterior vitreous cortex and the inner retinal surface was found, OCT scans showed an increased reflectivity of the inner retinal surface (Fig 1B, PVD eye). In cases in which focal areas of cleavage between the posterior vitreous cortex and the inner retinal surface were detected, OCT showed a thick, intravitreal hyper-reflective membrane partially adherent to the inner retina (Fig 1B, PVS eyes 1 and 2).

Surgical Procedures

Eyes with PVD with no evidence of vitreous traction, as observed by biomicroscopy, ultrasound, and, in some cases, OCT examination, were considered for pneumatic retinopexy (group 1A, 25 eyes). The treatment consisted of the injection of 1.5 to 2.5 cm^3 of sterile 18% sulfahexafluoride into the vitreous cavity via the pars plana using a 20-gauge needle under topical anesthesia. The gas injection was performed at the same time as the external drainage of the subretinal fluid by means of the perforation of the thin, posterior sclera with an atraumatic needle in a site corresponding to an area of choroidal atrophy. After surgery, patients were positioned facedown for 4 to 7 days, depending on the persistence of gas in the vitreous cavity. Eight to 10 diode laser spots were

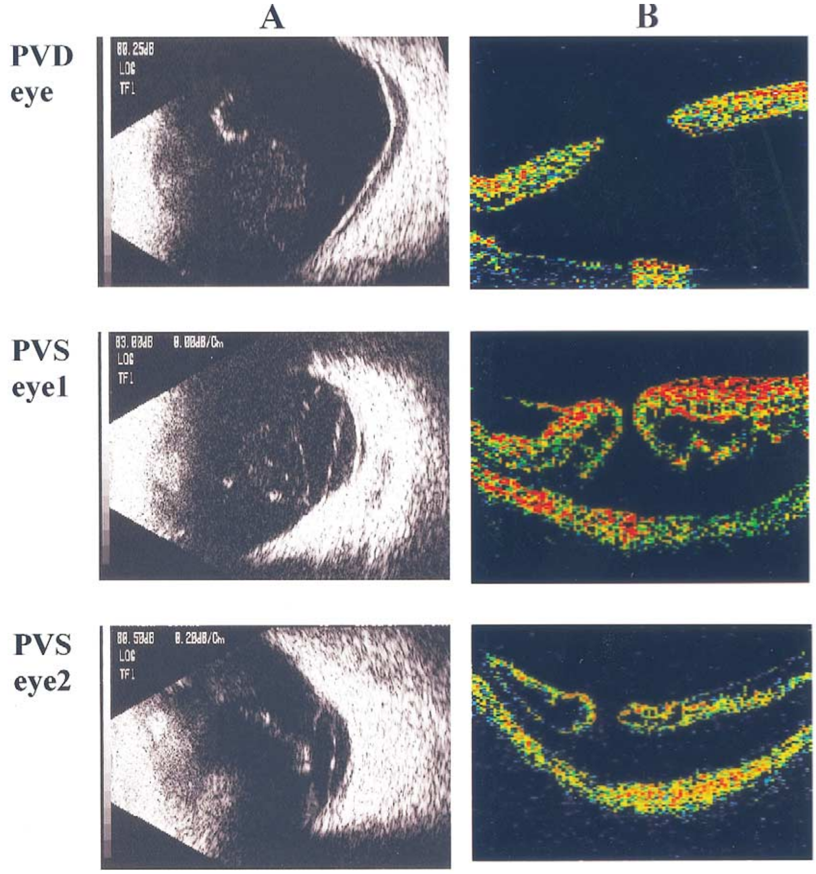

Figure 1. Examples of B-scan ultrasonography (**A**) and optical coherence tomography (OCT) (**B**) of retinal detachment (RD) with a macular hole (MH) in highly myopic eyes with posterior vitreous detachment (PVD eye) and posterior vitreous schisis (PVS eyes 1 and 2). **PVD eye**, Longitudinal B-scan ultrasonography of the inferotemporal meridian (**A**) shows an RD involving the posterior pole. Note the anterior displacement of the detached vitreous body, the extension of the RD towards the equator of the globe, and the echolucent retrovitreal space in contrast to the low reflectivity of the subretinal fluid. Wide aftermovements are elicited by kinetic ultrasonography. The OCT scan (**B**) shows absence of retinal reflectivity in the central macular area, rare hyporeflective intraretinal spaces, and absence of reflectivity between the neurosensory retina and the retinal pigment epithelium/choriocapillaris layer, consistent with the presence of an MH. **PVS eye 1**, Longitudinal inferotemporal B-scan ultrasonography (**A**) shows 2 vitreal membranes detectable from left to right, which correspond to the anterior and posterior aspects of the vitreous pocket, respectively, the second one being partially detached from the inner retina. The vitreous lacuna appears echolucent, whereas there is low reflectivity in the preretinal space. The OCT scan (**B**) shows a thick, intravitreal hyper-reflective band partly adherent to the inner retinal surface, consistent with the presence of focal areas of cleavage of the posterior vitreous cortex. A wide disruption of the neuroretinal layers can be observed. **PVS eye 2**, Vertical axial B-scan ultrasonography (**A**) shows a very shallow RD with a subclinical MH, as confirmed by OCT examination (**B**). At the biomicroscopic examination, this eye simulated a PVD due to the relative density of the anterior wall of the schisis and to the presence of a paracentral, ringlike opacity that was confused with the Weiss ring. The external layer of cortical vitreous was partially detached from the inner retina. The OCT scan (**B**) shows a thick, intravitreal hyper-reflective band partly adherent to the inner retinal surface, consistent with the presence of focal areas of cleavage of the posterior vitreous cortex. A disruption of the neuroretinal layers can be observed.

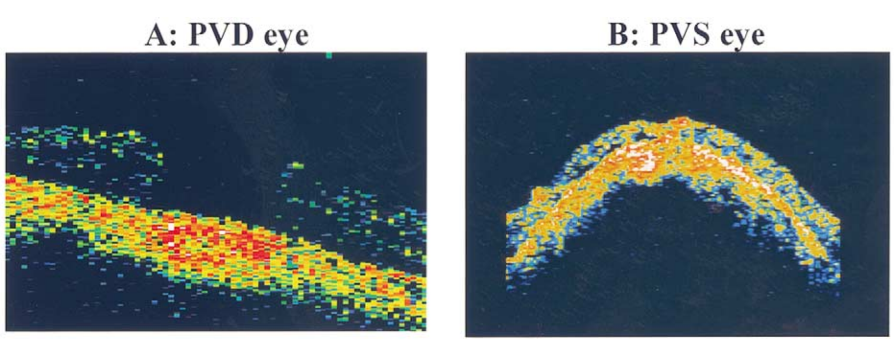

Figure 2. Examples of postoperative optical coherence tomography (OCT) in 1 patient with posterior vitreous detachment (PVD) (**A**) who underwent vitrectomy and 1 patient with posterior vitreous schisis (PVS) (**B**) who underwent scleral buckling of the macular region. **A**, Postoperative OCT examination showed an intimate attachment of the neurosensory retina to the retinal pigment epithelium (RPE) with minimal intraretinal hyporeflectivity and a flattening of the macular hole (MH) after successful reattachment. An enhanced optical backscatter signal was observed beneath the MH from the RPE/choriocapillaris layer due to the increased penetration of the incident and reflected light through that region. **B**, Postoperative OCT examination showed an intimate attachment of the neurosensory retina to the RPE with normal intraretinal reflectivity and a complete closure of the MH after successful reattachment.

placed using the indirect ophthalmoscope laser delivery system along the margins of the macular area in all 25 eyes 2 or 3 days after surgery.

Posterior vitreous detachment eyes in which vitreous traction, incomplete PVD, vitreous veils, or strands were detected over the inner retinal surface were treated by vitrectomy (group 1B, 35 eyes) rather than pneumatic repair.

The procedure consisted of a standard 3-port pars plana vitrectomy. In 30 of 35 eyes showing extensive RD, the subretinal fluid was drained with a tapered needle placed through a small hole in the peripheral retina. In 31 of 35 of these eyes, an 18% sulfahexafluoride mixture was injected into the vitreous cavity for internal tamponade, whereas 4 eyes with a more rigid retina had 1000-centistoke silicone oil (SO) for longstanding internal tamponade. Eight to 10 argon laser spots were in all cases placed intraoperatively on the edges of the macula with the endolaser.

In PVS eyes in which a posterior epiretinal membrane was observed, a standard 3-port pars plana vitrectomy was performed (group 2A, 49 eyes). In addition to the surgical method described for group 1B patients, vitrectomy included the removal of thin, translucent posterior epiretinal membranes, which in most cases extended over the entire posterior pole. Eight to 10 argon laser spots were placed intraoperatively along the edges of the macula in these patients. Finally, the vitreous cavity was filled with a mixture of 18% sulfahexafluoride gas (25 of the 49 eyes) or 1000-centistoke SO (24 of 49 eyes). Twenty-four eyes were filled with SO because it was impossible to remove the posterior wall of the vitreous lacuna completely or because the posterior retinal pigment epithelium was severely atrophic.

In PVS eyes in which intimate attachment of the posterior epiretinal membrane to the inner retinal surface was previously detected by OCT examination, or severe atrophy of the pigment epithelium was observed, scleral buckling of the macular region was performed (group 2B, 11 eyes). A solid 5×5-mm silicone rubber segment was placed across the macular region, using mattress sutures with 6-0 braided nylon. Subretinal fluid was drained with an atraumatic needle through an atrophic chorioretinal area before closing the mattress suture. No laser treatments or cryotreatments were performed over the macular region. During the drainage of the subretinal fluid, a variable amount of air was injected into the vitreous cavity to restore the intraocular pressure.

Silicone oil was removed from all of the 4 eyes of group 1 and from 20 of the 24 eyes of group 2 (the SO was not removed from 4 eyes because of the presence of ocular hypotension or extensive or diffuse choroidal atrophy) after an average of 3.1±0.7 months. If visually significant lens opacities developed during the 180 days of follow-up, the cataract was removed by phacoemulsification.

In all patients, indirect binocular ophthalmoscopy, ultrasonographic A-scan and B-scan examinations, OCT, and VA evaluation were performed 6 months after surgical procedures.

Upon recruitment, each patient gave informed consent to the surgical or diagnostic procedures. The research followed the tenets of the Declaration of Helsinki.

Statistics

The differences between the preoperative and postoperative VA values observed in each group have been evaluated by 1-way analysis of variance. A P value of <0.01 was considered significant. The relationship between preoperative and postoperative VA values has been considered as the percentage increase in VA ([postoperative VA − preoperative VA]/preoperative VA) × 100.

Table 2. Recovery of Visual Acuity (VA) Expressed as Percentage Increase with Respect to the Preoperative Values at 6 Months after Surgery in Eyes with Retinal Detachment and Macular Hole

Group*	Percentage Increase in VA with Respect to the Preoperative Value in All Eyes of the Group	Eyes in Which Anatomical Success Was Obtained	Percentage Increase in VA with Respect to the Preoperative Value in Eyes in Which the Anatomic Success Was Obtained
1A, N = 25	266.2 ± 202.7	23	289.3 ± 177.6
1B, N = 35	286.3 ± 239.8	31	334.6 ± 167.3
2A, N = 49	67.4 ± 89.9	45	73.4 ± 62.2
2B, N = 11	76.9 ± 53.6	8	105.7 ± 38.2

N = no. of eyes in the study group.
*1A: posterior vitreous detachment (PVD), pneumoretinopexy; 1B: PVD, pars plana vitrectomy; 2A: posterior vitreous schisis (PVS), pars plana vitrectomy; 2B: PVS, posterior episcleral buckle.

Results

Postoperative OCT examination showed an intimate attachment of the neurosensory retina to the retinal pigment epithelium (RPE), the intraretinal reflectivity ranged from reduced to normal, and a flattening of the MH was seen after successful reattachment. An enhanced optical backscatter signal was observed beneath the MH from the RPE/choriocapillaris layer due to the increased penetration of the incident and reflected light through that region. Examples of postoperative OCT in PVD and PVS eyes are shown in Figure 2.

Anatomical success, defined as a totally reattached neurosensory retina to the RPE at the last follow-up examination, was obtained in 23 of 25 (92%) eyes of group 1A, 31 of 35 (88.5%) eyes of group 1B, 45 of 49 (91.8%) eyes of group 2A, and 8 of 11 (72.7%) eyes of group 2B.

In patients with or without surgical success, at 180 days after surgery we assessed the postoperative visual outcome with respect to the preoperative values.

Postoperative VA outcomes, compared with the preoperative ones for all eyes of each group and for the eyes of each group in which the anatomic success was obtained, are shown in Table 2. Figure 3 shows the increase in VA in the eyes of each group in which the anatomic success was obtained.

A significant ($P<0.01$) improvement of the postoperative VA was observed in all groups. However, in eyes with PVD (group 1) there was a greater, statistically significant ($P<0.001$) percentage increase of postoperative VA with respect to eyes with PVS (group 2). The comparison of the postoperative increase of VA between the subgroups (1A vs. 1B and 2A vs. 2B) showed better results for group 2B ($P<0.001$).

Discussion

The vitreous probably plays a key role in the pathogenesis of most RDs, and eyes with high myopia and MH are no exception. Some controversies still arise with regard to RD associated with MH, particularly in cases of eyes with high

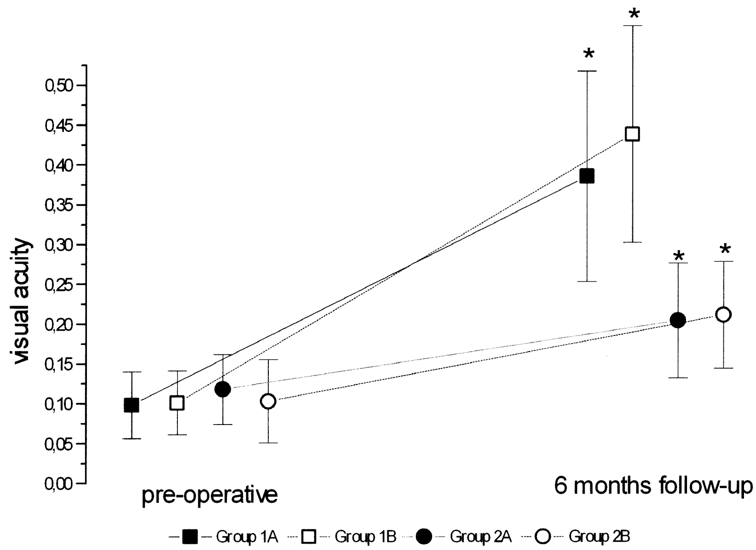

Figure 3. Graphic representation of mean values of visual acuity observed during the preoperative evaluation and after 6 months of follow-up in the eyes in which anatomic success was obtained. Group 1A: posterior vitreous detachment (PVD), pneumoretinopexy; group 1B: PVD, pars plana vitrectomy; group 2A: posterior vitreous schisis (PVS), pars plana vitrectomy; group 2B: PVS, posterior episcleral buckle. The vertical line represents 1 (±) standard deviation of the mean. 0.50 = 20/40; 0.45 = 20/44; 0.40 = 20/50; 0.35 = 20/57; 0.30 = 20/67; 0.25 = 20/80; 0.20 = 20/100; 0.15 = 20/133; 0.10 = 20/200; 0.05 = 20/400. *$P<0.05$, analysis of variance with respect to the preoperative values.

myopia, in which anatomical conditions, such as posterior staphyloma and areas of choroidal and retinal pigment epithelium atrophy, may also be involved. These anatomical modifications, according to some authors, are the only causes responsible for the onset of RD with MH in eyes with high myopia.[3]

Although it is not easy to explain the anatomical details observed with the various diagnostic examinations that allow the differentiation of PVD and PVS, we feel that the vitreoretinal relationship is particularly significant in determining the clinical picture and should influence the surgical procedures adopted. In our experience, a more reliable diagnosis comes from the combined interpretation of the results of every single examination and especially B-scan ultrasound and OCT scans, which allow in most cases a better definition of the vitreoretinal relationship.

Different surgical strategies were used based on the anatomical conditions: PVD eyes without vitreous tractions underwent pneumatic retinopexy; PVD eyes with vitreous traction, incomplete PVD, vitreous veils, or strands detected over the inner retinal surface were treated by vitrectomy; in PVS eyes in which a posterior epiretinal membrane was observed, a standard 3-port pars plana vitrectomy was performed; and in PVS eyes with intimate attachment of the posterior epiretinal membrane to the inner retinal surface, or with severe atrophy of the pigment epithelium, a scleral buckling of the macular region was performed.

In PVD eyes, the RD appeared to be elevated and frequently extended to the periphery, especially in the inferior quadrants. In many cases, the RD appeared to be supported by anteroposterior traction caused by vitreous strands (8 of 60 eyes) or by an incomplete PVD (14 of 60 eyes). In 37 eyes included in this group, however, no vitreous traction was detected preoperatively. Why RD is so extensive in these eyes remains unclear. Undetectable anteroposterior traction has been suggested.[5] Such forces let the liquefied vitreous flow into the subretinal space through the MH. In these eyes the MH appears to determine the onset of RD, which always turned out to be elevated and extended. Optical coherence tomography scans showed normal intraretinal reflectivity consistent with a well-preserved connection among the neuroretinal layers (Fig 1B, PVD eye).

In PVS eyes, the RD is less elevated and sometimes appears to be very subtle and shallow. In most cases, the detachment does not extend beyond the posterior pole. We believe that the MH is often not the only cause of RD in these patients. Optical coherence tomography scans were of great help for us in understanding the pathology affecting these eyes. In 56 of 60 examined eyes, a thin, hyperreflective epiretinal membrane exerting tangential traction on the macula was identified. The neurosensory layers appeared to be disrupted with wide intraretinal areas of minimal or no backscattering as the result of the tangential traction that we believe is often a feature of this pathology (Fig 1B, PVS eyes 1 and 2). Macular holes, sometimes barely identifiable with normal biomicroscopical observation, were detected by OCT examination.

The postoperative VA recovery observed in PVS eyes was more modest than in eyes with PVD. This could be ascribed to a major disruption of the retinal layers, as revealed by preoperative OCT examination, and a more severe atrophy of the RPE layer. Moreover, the PVS architecture occurs more typically in eyes with a higher degree of myopia, in which a posterior staphyloma is present. In these eyes, choroidal dysfunction may play a role. The better postoperative recovery of VA observed in PVD eyes relative to PVS eyes could be ascribed to a well-preserved connection between the neuroretinal layers, as revealed by preoperative OCT examination (Fig 1B), and to a lower degree of myopia associated with a lower incidence of posterior staphyloma. Although it is often possible to predict visual recovery in macula-off RD using a Potential Acuity Meter (Mentor O & O, Inc., Norwell, MA),[19] in patients with MH such an assessment would probably be of modest validity. The surgical procedure was performed no later than 3 days after the onset of the clinical symptoms in PVD eyes and no later than 3 days after the ophthalmoscopic diagnosis in PVS eyes. However, it is often impossible to establish precisely the time of onset of RD in PVS eyes. In these eyes, in fact, the tangential traction acts rather slowly, making the RD more insidious.

In conclusion, our findings suggest that, in highly myopic eyes, vitreous modifications play an important role in the pathogenesis and clinical features of RD with MH. Basing the surgical approach on these features seems logical, and may aid the surgeon in achieving better results for the patients.

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