Evaluation of Primary Surgical Procedures for Retinal Detachment with Macular Hole in Highly Myopic Eyes

A Randomized Comparison of Vitrectomy versus Posterior Episcleral Buckling Surgery

Guido Ripandelli, MD,[1] Andrea Maria Coppé, MD,[1] Romolo Fedeli, MD,[1] Vincenzo Parisi, MD[1,2,3]
Donald J. D'Amico, MD,[4] Mario Stirpe, MD[1]

Purpose: To evaluate postoperative outcomes between pars plana vitrectomy (PPV) and posterior episcleral buckle procedure (PEBP) in myopic eyes with retinal detachment (RD) and macular hole (MH).

Design: Retrospective nonrandomized comparative interventional trial.

Participants and Intervention: The study included 30 phakic, highly myopic eyes (from 19–30 negative diopters) of 30 patients with an RD and MH. The patients were divided into two groups: They were assigned to PPV (15 eyes, group A) or to PEBP (15 eyes, group B). No significant ($P > 0.01$) differences in preoperative visual acuity (VA) between group A and group B eyes were found. Follow-up was 12 months.

Main Outcome Measures: Anatomic attachment of the retina was determined, and VA was measured.

Results: Retinal reattachment was obtained on 11 of 15 (73.3%) eyes of group A and on 14 of 15 (93.3%) eyes of group B. In group A eyes the VA was substantially unmodified after surgical treatment, whereas in group B eyes the VA observed after surgical treatment increased significantly ($P < 0.001$) with respect to the preoperative values.

Conclusions: PEBP resulted in better postoperative anatomic and functional results compared with PPV in eyes with extreme degrees of myopia, pronounced posterior staphyloma, and posterior vitreous schisis affected with RD caused by MH. *Ophthalmology 2001;108:2258–2265 © 2001 by the American Academy of Ophthalmology.*

After Gonvers' and Machemer's[1] report in 1982, vitrectomy became the preferred technique for treatment of retinal detachment (RD) caused by macular hole (MH). Subsequently, simplified techniques such as pneumoretinopexis, with aspiration of fluid from the vitreous cavity close to the macular hole or external drainage of subretinal fluid were also introduced.[2,3]

In our practice, we observed that certain complex cases that failed with vitrectomy could be successfully repaired with a scleral buckle that was limited to the macular area. On the basis of this experience, this study examines and compares the anatomic and functional outcomes between pars plana vitrectomy (PPV) and posterior episcleral buckling procedure (PEBP) performed as primary surgery in highly myopic eyes with RD caused by MH.

Material and Methods

Patients

Between February 1997 and December 1998, we examined 118 highly myopic phakic eyes with RD caused by MH. For this study, a subgroup consisting of 30 consecutive eyes (of 30 patients) with the highest degree of myopia, defined as myopia of 19 negative diopters or greater, was selected. The degree of myopia observed in these 30 eyes before surgical treatment (see later) ranged from 19 to 30 negative diopters with a mean 24.7 ± 3.63 negative diopters. This group included 11 males and 19 females, and the age of the patients ranged from 42 to 66 years (mean age, 54.3 ± 7.0 years). Additional inclusion criteria were absence of proliferative vitreoretinopathy, no history of eye surgery, intraocular pressure lower than 20 mmHg, no history of diabetes or other systemic disease that might confound the visual results, and no history of

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[1] Fondazione G. B. Bietti per l'Oftalmologia, Rome, Italy.

[2] Cattedra di Clinica Oculistica, Universita' di Roma "Tor Vergata," Rome, Italy.

[3] AFaR-CRCCS, Divisione Oculistica Ospedale Fatebenefratelli, Isola Tiberina, Rome, Italy.

[4] Massachusetts Eye and Ear Infirmary, Harvard Medical School, Boston, Massachusetts.

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Reprint requests to Guido Ripandelli, MD, Via Pasubio 6, 00195 Rome, Italy.

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

Patients (eyes) number	30
Age	42–66 years (mean 54.3 ± 6.0)
Gender	11 Males; 19 females
Myopia	From 19 to 30 negative diopters (mean −24.7 ± 3.6)
Vitreous, retinal, and scleral findings	30/30 eyes: Deep posterior staphyloma. 22/30 eyes: PVS in form of a wide posterior vitreous lacuna or 2 or more confluent vitreous lacunae including the area of the posterior staphyloma. OCT examination: disruption of the neuroretinal layers of various degrees. In 6 of 22 eyes, increased backscattering of the inner retinal surface; in 16 of 22 eyes, a hyperreflective membrane partially separated from the inner retina. 8/30 eyes: PVD with residual posterior connections (3 eyes incomplete PVD, 5 eyes vitreous strands or veils between the detached vitreous and the posterior retina). OCT examination: normal reflectivity of the neuroretinal layers.
Extension of retinal detachment	14/30 eyes: Extended to the postequatorial region. 9/30 eyes: Limited at or slightly exceeding the area of staphyloma. 7/30 eyes: Extended to the periphery in the inferior quadrants.

OCT = optical coherence tomography; PVD = posterior vitreous detachment; PVS = posterior vitreous schisis.

ocular trauma. The details of the patients included in this study are summarized in Table 1. Informed consent was obtained from each patient enrolled in this study, and the research followed the tenets of the Declaration of Helsinki.

Examinations were performed for all patients preoperatively, and then postoperatively at 15 days, 1, 3, 6, 9, and 12 months. In all cases the following examinations were performed:

Best-corrected visual acuity (VA) assessed by Modified ETDRS Table (Lighthouse, Low vision products, Long Island City, NY); the VA has been expressed in logarithm of the minimum angle of resolution values obtained at the distance of 4, 2, 1, and 0.5 m.

Applanation tonometry.

Dilated indirect binocular ophthalmoscopy with scleral depression.

Slit-lamp examination supplemented with a plus 90-diopter lens.

Fundus photography.

Ultrasonographic A-scan and B-scan examination by means of a 10-MHz probe on an A/B scan system (Humphrey Instruments, San Leandro, CA).

In addition, optical coherence tomography (OCT, Humphrey Instruments, San Leandro, CA) was performed with a series of six horizontal and six vertical 4-mm length scans over the posterior pole after full pupillary dilatation. The principles of operation and the OCT technology have been previously reported elsewhere.[4,5]

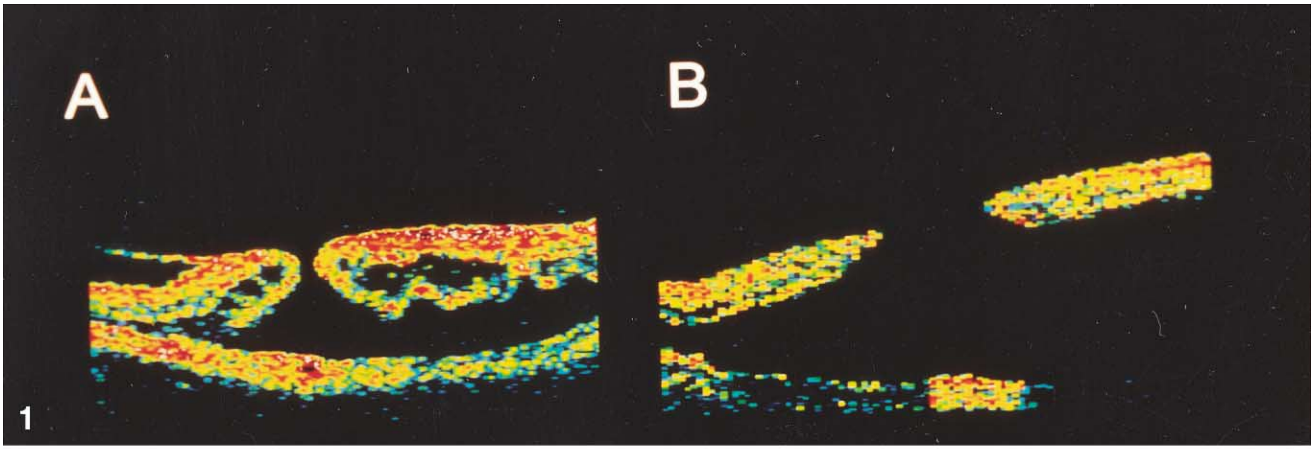
The vitreous was carefully examined in each patient for a posterior vitreous detachment or remaining vitreous attachments to the retina. In many patients, an empty space within the posterior vitreous or posterior vitreous schisis (PVS) was determined after identification of characteristic findings on both clinical and instrumental examinations. Biomicroscopy of PVS eyes showed a uniform, high-density layer of vitreous cortex that could be observed surrounding an empty space in the posterior vitreous, usually limited to, or slightly larger than, the area of the posterior staphyloma. This posterior vitreous cortical layer in PVS also lacked the saccadic movements characteristic of a posterior vitreous detachment.[6] Correspondingly, ultrasonographic examination showed a division of the outer posterior vitreous cortex, and OCT scans disclosed the adherent posterior wall of the vitreous lacunae characteristic of PVS, depicted as a moderately reflective band adherent to the inner retinal surface on the macular area (Fig 1A). In eyes with PVS, OCT scans showed the presence of areas of minimal or no reflectivity in the neuroretinal layers, consistent with a disruption of the detached retina (Fig 1A), whereas normal intraretinal reflectivity was depicted in eyes with posterior vitreous detachment (Fig 1B). In several eyes with PVS, the MH in the posterior detachment was best visualized by OCT and seemed to be parafoveal, although this determination is difficult to assess in these highly abnormal eyes.

Surgical Treatment

The 30 eyes were assigned to the following groups before surgery: group A, 15 eyes, in which a PPV was performed; and group B, 15 eyes in which a PEBP was performed.

Group A: PPV Surgical Treatment. At the beginning of surgery, a 2-mm silicone encircling buckle was positioned on the sclera corresponding to the equatorial region in all 15 eyes of this group; in addition, the lens was removed through the pars plana to obtain an accurate and complete removal of the vitreous base and a possible improvement of the surgical success rate. Preoperatively, 12 of the eyes were noted to have a detachment confined to the posterior pole, and in the remaining 3 eyes the detachment extended to the periphery. In all cases in which the detachment was confined to the posterior pole, drainage of subretinal fluid (which was particularly dense in all cases) was performed with a soft-tipped cannula through the hole as part of an air–fluid exchange (Fig 2). In the remaining 3 eyes with an extensive RD reaching the periphery, the fluid was drained through a retinotomy in the inferior quadrants at the periphery of the RD with simultaneous perfluorodecalin injection. The retinotomy was treated with the aforementioned encircling scleral buckle and retinopexy.

The cases were also treated differently on the basis of the presence of a PVS and the ability to remove all residual epiretinal tissue. After the removal of the vitreous gel, 12 of the 15 eyes were confirmed to have a PVS. In 8 of these 12 eyes with PVS, the thin, transparent epiretinal tissue that was extensively or partially attached to the posterior retina was removed. In these eyes, endodrainage of subretinal fluid through the macular hole was followed by the application of five to eight photocoagulation spots that were placed in a widely separated circle at the periphery of the macula and not at the margins of the macular hole. Intraocular air was then exchanged with 18% sulfur hexafluoride (SF6)/air mixture. In 4 of these 12 eyes with PVS, it was not possible to completely remove the dense posterior vitreous cortex from the surface of the retina. These eyes displayed a substantial rigidity of the posterior retina that prevented complete flattening of the retina into the bottom of



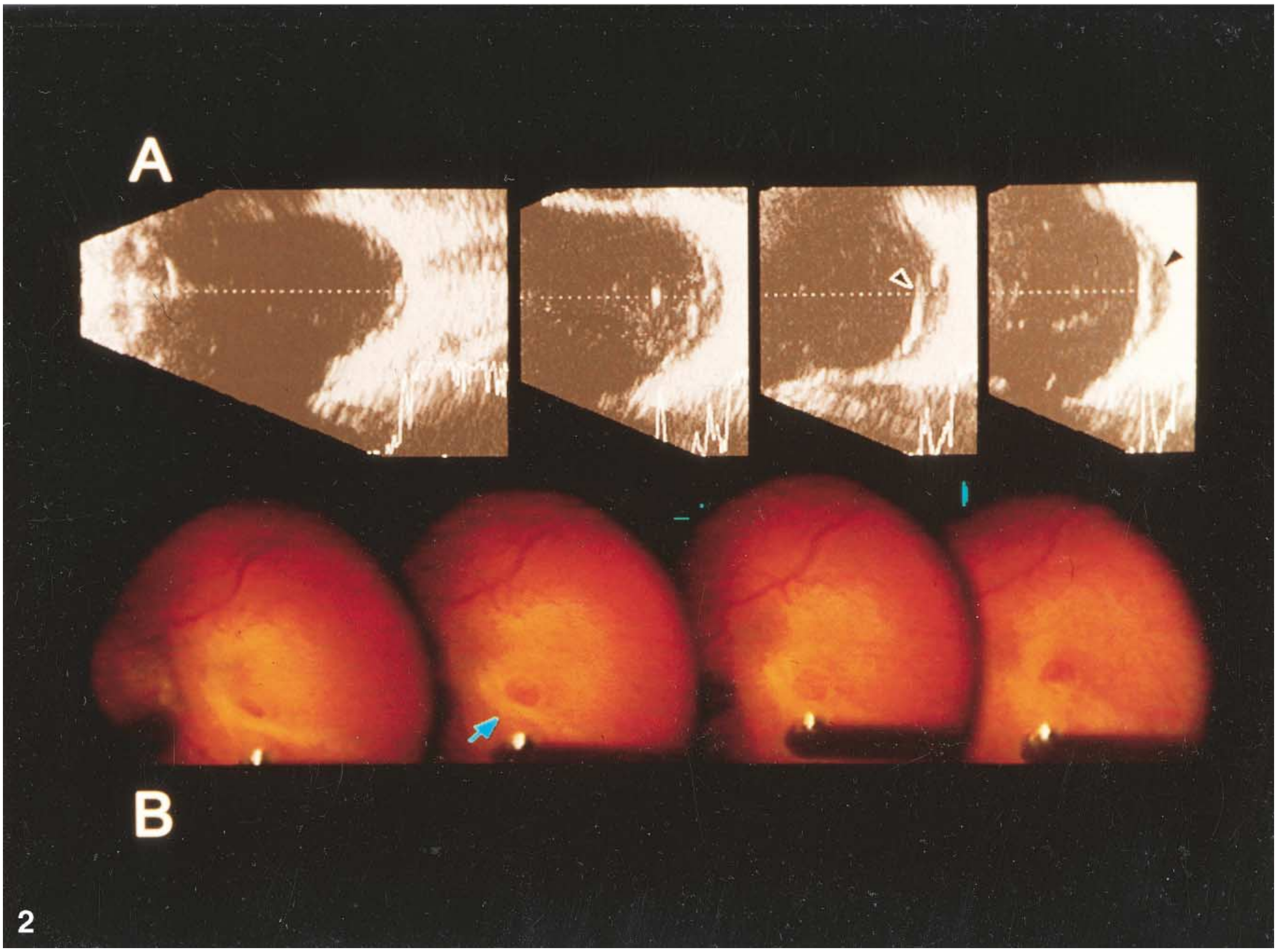


Figure 1. Optical coherence tomography (OCT) scans of highly myopic eyes with retinal detachment caused by macular hole (MH). **A,** OCT scan shows intraretinal areas of minimal or no reflectivity, consistent with a disruption of the neuroretinal layers surrounding the MH in eyes with a posterior vitreous schisis. **B,** OCT scan shows normal reflectivity of the neuroretinal layers in the macular area of eyes with a posterior vitreous detachment.

Figure 2. **A,** Preoperative ultrasonographic B-scan examination shows the presence of a not acoustically homogeneous fluid in the preretinal and subretinal space. **B,** Aspiration through the macular hole (MH) of thick subretinal fluid causes an enlargement of the MH.

the posterior staphyloma after a fluid–air exchange. In these eyes only, two or three laser spots were placed at the temporal margin of the MH itself to avoid placing photocoagulation in the peripheral macula that might contain residual attached vitreous cortex. Furthermore, silicone oil tamponade was used in these eyes in association with inferior peripheral iridectomy. Finally, in 3 of the 15 eyes, a clear PVS was not detected, but variable residual connections between the detached vitreous and the posterior retina

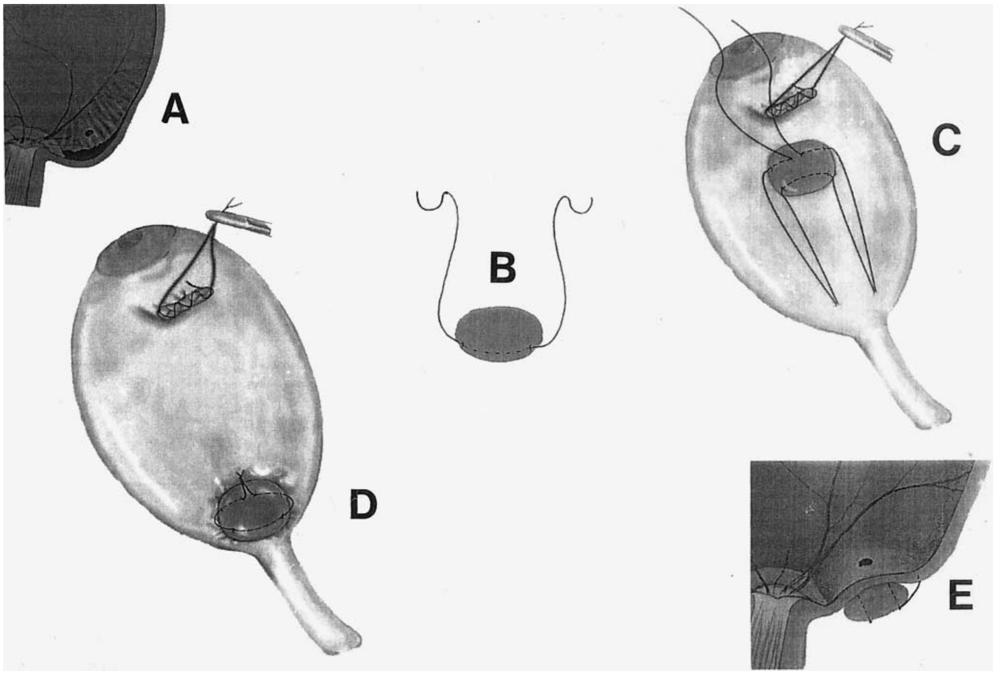


Figure 3. Posterior episcleral buckling procedure. **A,** Retinal detachment with macular hole (MH). **B,** A solid silicone exoplant is previously prepared with a 6-0 braided nylon suture. **C,** The needles are passed into the sclera 5 mm above and below the MH, and drainage is performed by means of one of the suture needles. **D–E,** The exoplant is drawn into position over the mark and the suture is tied.

were encountered and excised, and were otherwise treated identically to the eyes with complete removal of surface tissue.

Overall, in the 15 group A eyes, intraoperative complications were limited to a single eye with choroidal effusion that resolved spontaneously. All group A patients were asked to remain in the prone position for 7 to 10 days in the postoperative period. In all of the patients treated with SF6, a subsequent fluid–gas exchange was performed at the slit lamp between the fourth and the sixth postoperative day; this was facilitated because all the patients were aphakic.

Group B: PEBP Surgical Treatment. All 15 eyes in this group underwent a PEBP. For this procedure (see Fig 3**),** the lateral rectus muscle was temporarily detached from its insertion, and a suture was placed at the insertion site for ocular rotation. A scleral localizer was used in association with indirect ophthalmoscopy to mark the MH on the sclera, and the globe was rotated to visualize this mark. A solid silicone exoplant was trimmed to approximately $5 \times 5 \times 2$ mm in size and secured with a 6-0 braided nylon suture that was passed completely through the block along one of the 5-mm edges. The attached needles were passed into the sclera approximately 5 mm above and below the scleral mark, and drainage was performed by scleral puncture with one of the suture needles. The suture was tightened, drawing the exoplant into position over the mark, and the suture was permanently tied after an additional passage through the temporal postequatorial sclera. The exact position of the exoplant was verified by indirect ophthalmoscopy. No laser 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. In all the eyes an additional 2-mm high encircling scleral buckle was placed. As in group A, a single intraoperative complication in the form of choroidal effusion occurred in one eye.

Statistics. The differences between the preoperative and the postoperative VA values observed in each group have been evaluated by one-way analysis of variance. A *P* value less than 0.01 was considered significant.

Results

Anatomic success was defined as total reattachment of the neurosensory retina to the retinal pigment epithelium at the last follow-up examination (1 year postoperative). The mean values of VA are shown in Figure 4.

Group A

In the eyes that underwent PPV, anatomic success was achieved in 11 of 15 eyes (73.33%) after this single surgery. In these 11 successful cases, no complications occurred during the follow-up period, which was 1 year for all eyes in this study. The best postoperative VA was measured between 15 days and 6 months of follow-up with an average of 107.7 ± 51 days. The preoperative VA of 1.38 ± 0.35 increased to 1.10 ± 0.52 logarithm of the minimum angle of resolution values at 1 year, but the difference was not statistically significant ($P = 0.095$). The intraocular pressure in these eyes was stable between 9 and 18 mmHg (average, 12.3 ± 1.4 mmHg).

Four of the 15 eyes failed with initial surgery. In three of these four unsuccessful cases, the epiretinal membrane had been incompletely removed during the first surgery, and the retina redetached shortly after surgery, notwithstanding the silicone oil tamponade. In three eyes the retina was subsequently reattached by means of a PEBP without removal of the silicone oil. The final case failed because of extensive atrophy of all the area of the posterior staphyloma with presumed dysfunction of retinal pigment epithelium/retinal adhesion, and further surgery was not performed.

After 1 year of follow-up of the 11 successful cases, OCT

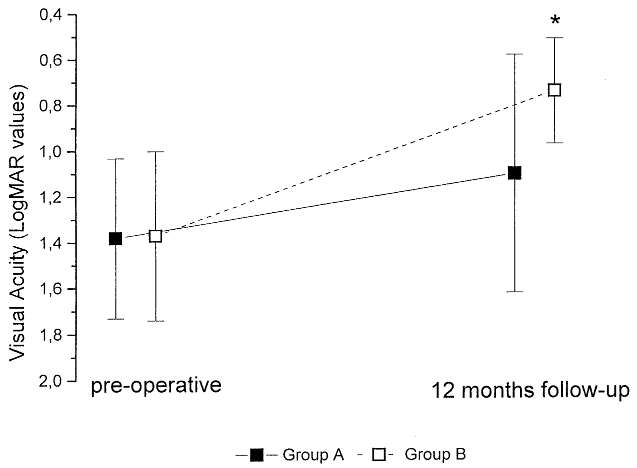


Figure 4. Graphic representation of mean values of visual acuity expressed as logarithm of the minimum angle of resolution (logMAR) values observed at the preoperative evaluation and after 12 months of follow-up in highly myopic eyes affected by retinal detachment and macular hole. Group A: eyes treated by pars plana vitrectomy; Group B: eyes treated by posterior episcleral buckling procedure. Vertical lines represent one (±) standard deviation of the mean. * = $P < 0.01$, analysis of variance with respect to the preoperative values.

showed a complete attachment of the retina to the retinal pigment epithelium. In 7 of the 11 eyes, OCT showed normal intraretinal reflectivity with a flattening of the margins of the MH and persistence of foveal defect (Fig 5A1, 5A2). In the remaining 4 successful cases, OCT showed intraretinal spaces of minimal or no reflectivity consistent with the persistence of a certain amount of intraretinal edema. The remaining myopia in the 10 eyes without silicone oil in the vitreous cavity ranged between 2 and 7 negative diopters (average, 4.5 negative diopters).

Group B

In the eyes that underwent PEBP, anatomic success was obtained in 14 of 15 cases (93.3%) after the single surgery. The sole unsuccessful case was repaired by vitrectomy with silicone oil. In the 14 initially successful cases, no complications occurred during the follow-up period. The best final VA recovery was measured between 3 and 9 months of follow-up, with an average of 186.9 ± 68 days. The preoperative VA of 1.37 ± 0.37 was significantly increased to 0.74 ± 0.23 logMAR values at 1 year ($P < 0.001$). The intraocular pressure in these eyes was stable between 11 and 18 mmHg (average, 14± 1.5 mmHg) during the follow-up period.

After 1 year of follow-up of the 14 successful cases, OCT scans showed a complete reattachment of the neurosensory retina to the retinal pigment epithelium with no evidence of the MH, and a convex profile of the scanned retina caused by the episcleral buckle (Fig 5B1, 5B2). In three eyes a separation of a thin layer of vitreous cortex from the posterior retina over the scleral buckle

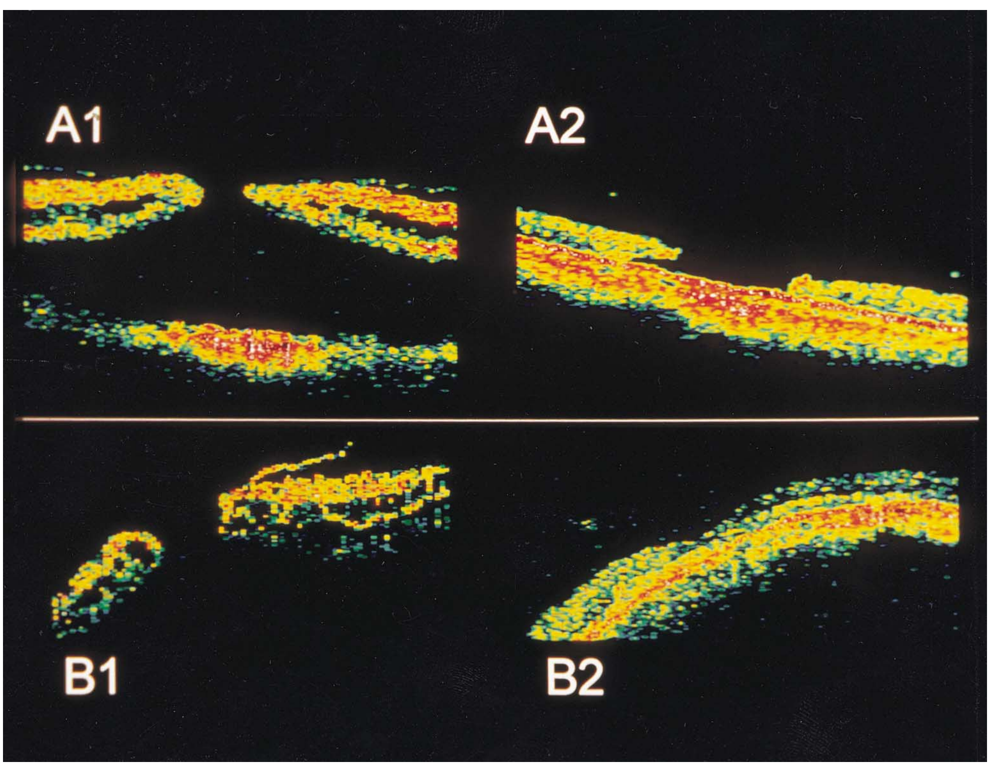


Figure 5. Preoperative (**A1, B1**) and postoperative (**A2, B2**) evaluation with optical coherence tomography (OCT). **A1, B1,** Preoperative OCT scan shows absence of retinal reflectivity in the central macular area, large hyporeflective intraretinal spaces and absence of reflectivity between the neurosensory retina and the retinal pigment epithelium (RPE)/choriocapillaris layer, consistent with the presence of a macular hole with disruption of the neuroretinal layers and retinal detachment. A hyperreflective band adherent to the inner retinal surface is represented, consistent with the presence of posterior vitreous cortex. **A2,** Postoperative OCT of myopic eye that underwent pars plana vitrectomy. The neurosensory retina is well attached to the RPE/choriocapillaris layer with normal intraretinal reflectivity. Absence of retinal reflectivity in the foveal area indicates the persistence of the macular hole. **B2,** Postoperative OCT scan of myopic eye that underwent posterior episcleral buckling procedure. A convex retinal profile caused by the macular buckle with normal intraretinal reflectivity and no evidence of foveal defect is observed.

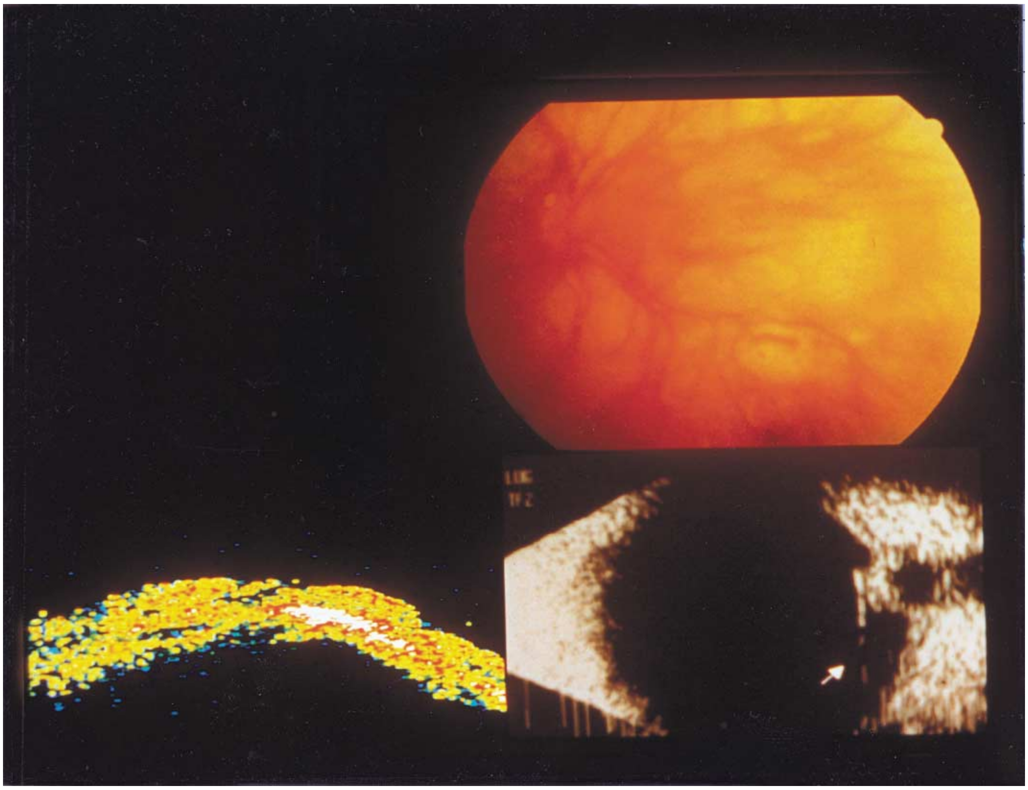


Figure 6. Postoperative fundus photograph, optical coherence tomography (OCT), and ultrasonographic B-scan examination in one myopic eye that underwent posterior episcleral buckling procedure. Ultrasonographic postoperative examination shows a late, spontaneous separation of the posterior vitreous cortex.

developed between 3 and 12 months of follow-up (Fig 6). In these eyes OCT scans did not show abnormal reflectivity over the inner retinal surface, presumably caused by signal absorption by the overlying vitreous.

Discussion

The aim of surgery for RD caused by a MH has focused primarily on the anatomic reattachment of the retina and the ease with which it might be accomplished. To achieve this result, many different techniques have been used and have changed considerably as vitreoretinal surgery has evolved. Initial surgical approaches consisted of creating a scleral buckling effect involving the macular area without the use of posterior sutures. These procedures were generally combined with treatment of the MH by retinopexy with cryotherapy, diathermy, or laser photocoagulation.[7–9] The extensive scarring produced by these treatments limited the functional result to peripheral vision only.

In 1982, Gonvers and Machemer[1] reported for the first time successful treatment of RD caused by an MH using vitrectomy without photocoagulation. Later, Gonvers[10] further reported vitrectomy alone was not effective in the subgroup of cases in which the MH and RD occurred in highly myopic eyes. A modified procedure that combined vitrectomy with minimal laser photocoagulation of MH and long-term silicone oil tamponade has been described[11]; the average myopia in the reported series was 17.7 ± 1.1 negative diopters.

In our study we selected 30 consecutive cases of RD caused by an MH with myopia of 19 or more negative diopters, and the average myopia was 24.77 ± 3.6 negative diopters. The surgical success rate was 73.33% in PPV eyes and 93.33% in PEBP eyes. Most significantly, the postoperative VA was better in eyes that received a PEBP. The complications were the same in the two groups: in one eye of each group there was choroidal effusion during surgery, and both spontaneously resolved.

Our series included a group of eyes with an unusually high degree of myopia. The severe anatomic abnormalities encountered in these eyes undoubtedly contributed to the pathogenesis of RD with MH. In all of these eyes, there was a pronounced posterior staphyloma with extensive areas of choroidal and pigment epithelial atrophy, and in 22 of the 30 eyes (73.3%) there was a PVS. The detachment of the posterior retina that was limited to the postequatorial region in most of our cases clearly originated by tangential traction from a dense layer of the posterior vitreous cortex.

Several reasons might explain the better results achieved in eyes after our modified scleral buckling procedure, which was limited to the macular area without retinopexy treatment of the MH. First, pathologic surface traction presumably acts for a long time, as evidenced by the fact that an abnormal separation of the neuroretinal layers in the macula of eyes with PVS could be confirmed in many cases by OCT (see Fig 1A), a finding that is not encountered in other forms of retinal detachment. The absence of such a separation in eyes with a posterior vitreous detachment further supports this hypothesis (see Fig 1B). This disruption of the neuroretina was resolved after PEBP, but persisted, though reduced, after PPV as observed by OCT. Second, the relief of surface traction was more easily achieved by PEBP than by PPV in our series. Despite our concentrated efforts to completely remove all residual epiretinal tissue during PPV, in four eyes with PVS this was not achieved, and all of these eyes failed, despite the use of silicone oil to flatten the retina completely. Interestingly, three of these cases were successfully reattached with PEBP. Third, endodrainage of subretinal fluid, which was particularly thick in all of these cases, was performed through the MH itself in most cases treated with vitrectomy. This maneuver may damage visually critical photoreceptors or enlarge or displace the MH (see Fig 2). These potential adverse effects may be the consequence of the passage of thick subretinal fluid through the hole or the result of forcing the retina to conform to a deep posterior staphyloma. Specifically, we observed the extension of a parafoveal hole into the previously uninvolved foveal area in certain cases treated with PPV. Fourth, despite reattachment of the retina in successful cases, OCT examination disclosed a postoperative foveal defect in eyes that underwent PPV (see Fig 5 A2), whereas a posterior defect could no longer be identified in eyes that were treated with PEBP (see Fig 5 B2). Fifth, a separation of presumed posterior vitreous cortex was observed during the postoperative period in three eyes that were treated with PEBP (see Fig 6). This finding suggests that the effect of the scleral buckle in reducing the posterior staphyloma and focally indenting the epicenter of tangential traction may facilitate the release of residual epiretinal membrane. Although we did not compare various buckle materials, it is our impression that solid silicone is preferable to sponges[12] to reliably produce a high and discrete indentation of the macular region.

We are aware that PEBP is perhaps more technically challenging than PPV and may even be considered outdated by many. Nevertheless, the superior visual results obtained in our series strongly suggest that this procedure be considered in the armamentarium of operations for RD with MH, particularly in cases with extreme degrees of myopia, with pronounced posterior staphyloma and the presence of a PVS. It is understood that applying a buckle to the posterior pole of a highly myopic eye with thin sclera and a large staphyloma is potentially dangerous, and it is clear that familiarity with this modification of buckling technique is necessary to achieve visually successful outcomes. In our experience, PEBP had a minimal complication rate and did not differ significantly in morbidity from PPV. Although this study evaluated PEBP as a primary procedure for repair of RD with MH in high myopia, its use as a secondary procedure in cases that fail after PPV is potentially attractive as well. It is also possible that future modifications of vitrectomy technique may also offer improved visual results. In any event, it is our hope that visual outcomes, and not simply ease of reattachment, remain the ultimate consideration in the treatment of RD with MH in high myopia.

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