Retinectomy for Recalcitrant Retinal Detachments

V.B.6.

Lawrence P. Chong

Outline

I. **Introduction**

II. **Pathophysiology**

III. **Surgical Approach**
- A. Retinotomy and Retinopexy
- B. Vitreous Substitutes
- C. Complications

IV. **Future Developments**
- A. Surgical
- B. Pharmacologic

References

L.P. Chong, MD
Department of Ophthalmology, Doheny Eye Institute, Los Angeles, CA, USA

VMR Institute for Vitreous Macula Retina, Huntington Beach, CA, USA
e-mail: lchong@usc.edu

Keywords
Vitreous base • Retinal detachment • Proliferative vitreoretinopathy (PVR) • Vitrectomy • Retinectomy

Key Concepts
1. Anterior PVR membranes transmit traction to the retina and ciliary body via the arcuate fibers of the vitreous base, the "anterior loop".
2. The firm adhesion of vitreous to peripheral retina makes it impossible to surgically separate the two structures.
3. Retinectomy is currently the treatment of choice for severe anterior PVR, although the future may see pharmacologic vitreolysis as adjunctive therapy to decrease vitreoretinal adhesion and facilitate removal of vitreous and PVR membranes.

I. Introduction

Anterior proliferative vitreoretinopathy (PVR) is the greatest challenge facing the surgeon attempting to repair recurrent retinal detachment [1]. The Retina Society recognized this and, to create a more prognostic classification, added anterior proliferation distinct from posterior proliferation (extensive macular pucker) to its ABCD classification of PVR [2] (Table V.B.6-1). The traction forces at the vitreous base were classified as circumferential or anterior (Figure V.B.6-1), acknowledging the complexity of contraction of fibrous tissue formation in this zone. Machemer first described retinotomy in 1981 [3] for incarcerated retina in a ruptured globe. Zivonovich described its application for severe traction membranes [4]. Subsequent reports followed [5–9] and emphasized the importance of removing retina anterior to the retinotomy

J. Sebag (ed.), *Vitreous: in Health and Disease*,
DOI 10.1007/978-1-4939-1086-1_43,

to prevent re-proliferation, extending the retinotomy to an adequate size, the importance of long-term tamponade, and the benefit of perfluorocarbon liquids. In the PVR Silicone Oil Study, retinotomy was performed in 29 % of cases [10] .

Table V.B.6-1 Proliferative vitreoretinopathy described by contraction type and location

Grade C proliferative vitreoretinopathy		
Type	Location (in relation to equator)	Features
1. Focal	Posterior	Starfold posterior vitreous base
2. Diffuse	Posterior	Confluent starfolds posterior to vitreous base. Optic disk may not be visible
3. Subretinal	Posterior/ anterior	Proliferations under the retina: annular strand near disk; linear strands; motheaten-appearing sheets
4. Circumferential	Anterior	Contraction along posterior edge of vitreous base with central displacement of the retina; posterior retina in radial folds
5. Anterior displacement	Anterior	Vitreous base pulled anteriorly by proliferative tissue; peripheral retinal trough; ciliary processes may be strected, may be covered by membrane; iris may be retracted

Proliferative vitreoretinopathy described by contraction type and location. (From page 161 Machemer et al. [2])

II. Pathophysiology

The cellular aspects of PVR pathogenesis are discussed in chapter III.J. Cell proliferation at the vitreoretinal interface in PVR and related disorders. It is important to appreciate that the proliferation of cells and formation of PVR membranes are influenced by the underlying structures of the vitreous cortex (see chapter II.E. Vitreoretinal interface and ILM) that creates surfaces upon which membranes form. The orientation of collagen fibrils within the vitreous base influences the vector of forces generated by contracting PVR membranes. The Retina Society classification of anterior traction being "circumferential" or "anterior" reflects the fact that the underlying structure of the vitreous base is an important component of the phenomenon. (see Table V.B.6-1) Circumferential traction arises from the entire vitreous base, a three-dimensional doughnut-like structure that straddles the ora serrata 360°. Within the vitreous base is a dense network of collagen fibrils that insert anterior and posterior to the ora serrata (Figure V.B.6-1). Because of the strong adherence of the vitreous to the retina in this area [11, 12], it is impossible to detach the vitreous at the vitreous base. Therefore, it is impossible to peel membranes in this area.

The collagen fibers of the vitreous base form a loop, called the "anterior loop" which connects the peripheral retina and the pars plana of the ciliary body (Figure V.B.6-2).

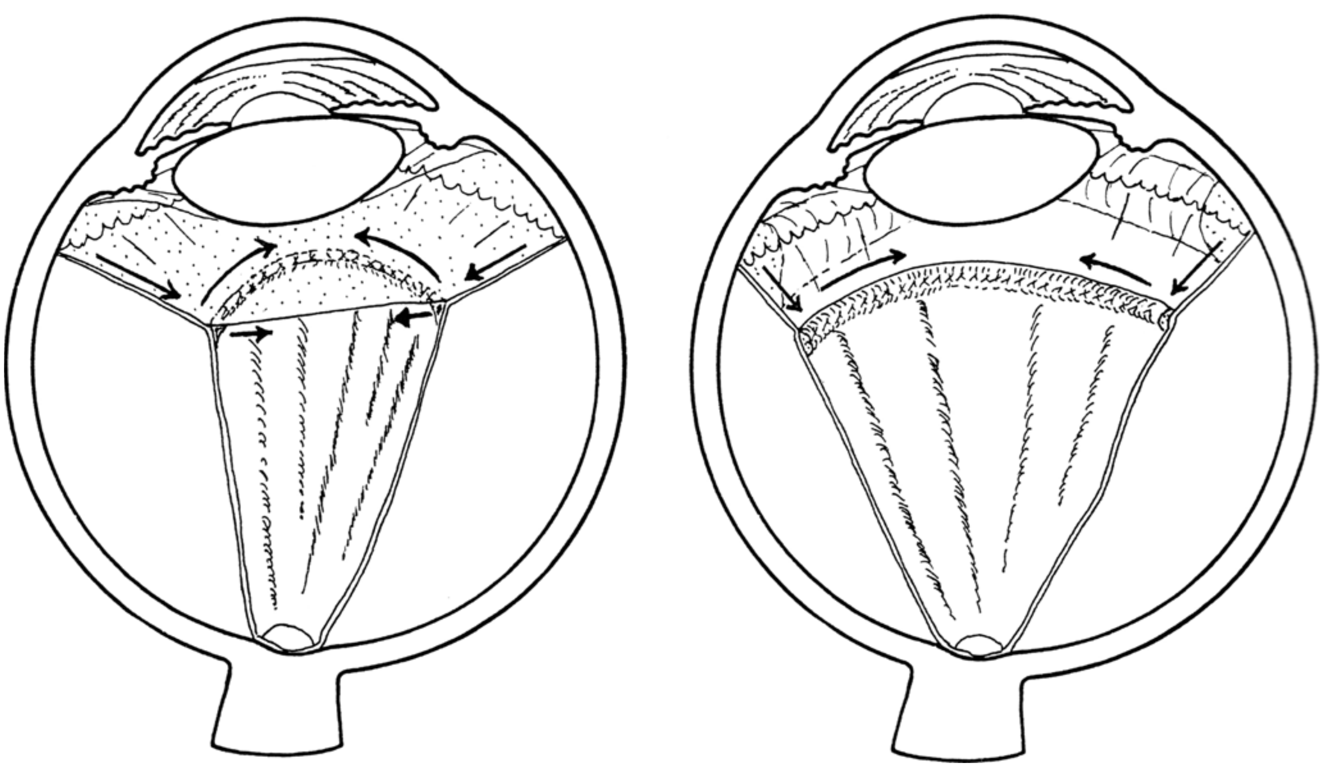

Figure V.B.6-1 Circumferential traction (From p 163 Machemer et al. [2])

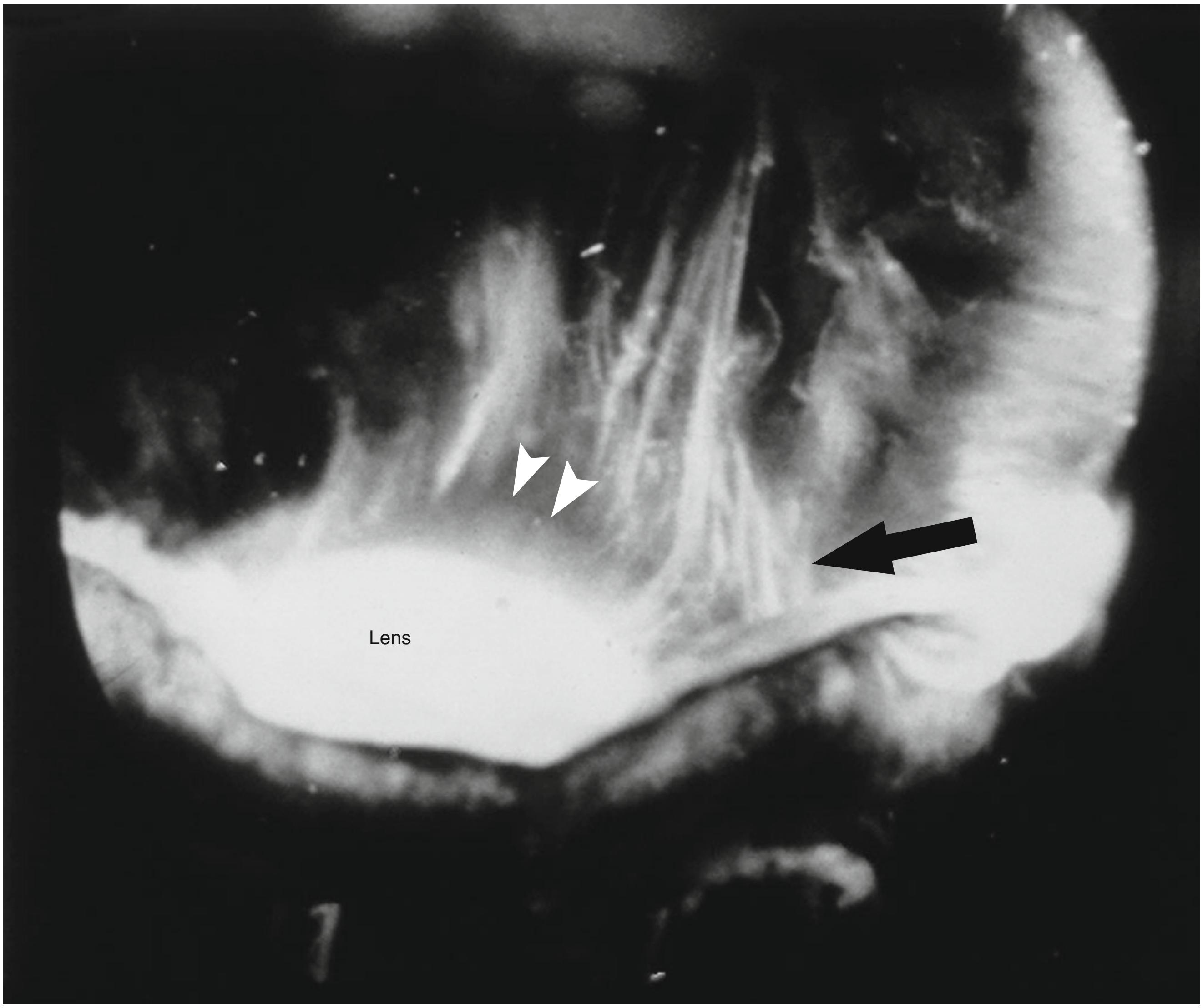

Figure V.B.6-2 Human vitreous base. After dissection of the sclera, choroid, and retina, the vitreous body of this 57-year-old man is left attached to the anterior segment, and the specimen is illuminated with dark-field slit microscopy. The vitreous base (*black arrow*) is seen surrounding the lens and consists of a dense matrix of collagen fibrils that splay out to insert anterior and posterior to the ora serrata (*white arrowheads*) (courtesy of J. Sebag, MD of the VMR Institute for Vitreous Macula Retina)

Contraction of PVR membranes in the peripheral anterior vitreous thus transmits traction to adjacent structures. When the ciliary body detaches, it ceases to synthesize the aqueous and the result is hypotony. If traction is extensive, there can even be iris retraction. Perpendicular traction mediated by the anterior loop (Figure V.B.6-2) rolls the anterior retina forward onto the pars plana and foreshortens the retina usually inferiorly where retinal pigment epithelial cells preferentially settle and proliferate. For this reason, the retina can detach posterior to a broad and high inferior scleral buckle. Retinal reattachment rates improved when removal of crystalline lenses improved access to the vitreous base, and techniques were developed to better visualize this zone and to dissect membranes in this area thereby freeing up foreshortened retina.

III. Surgical Approach

In many cases, the retina remains foreshortened even after aggressive dissection, and the retina must be cut to allow the posterior retina to settle.

A. Retinotomy and Retinopexy

The location of the retinotomy should be posterior to all present and future contraction and therefore posterior to the vitreous base. Panoramic viewing systems provide an excellent view of the peripheral retina for this purpose. In the presence of a scleral buckle, the retinotomy can be made

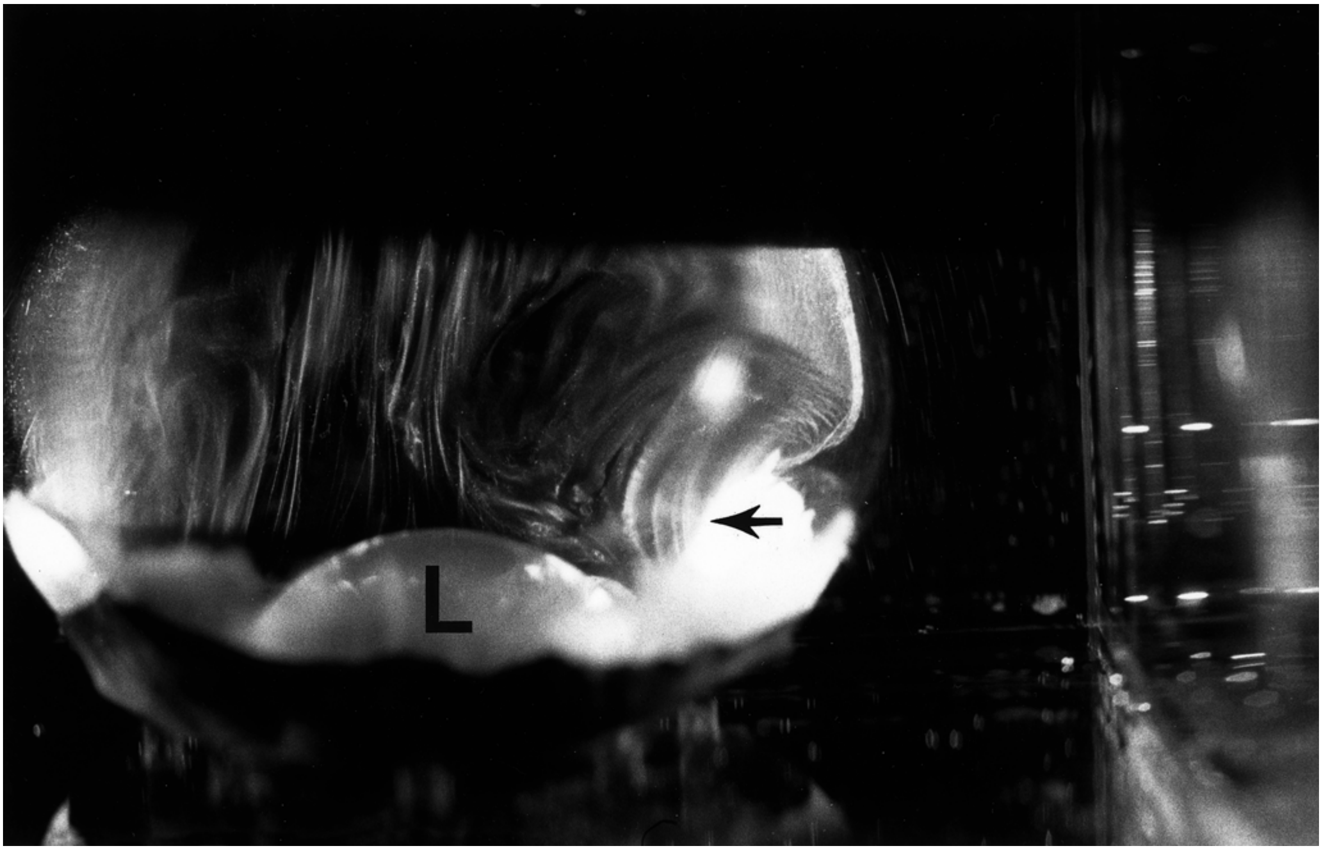

Figure V.B.6-3 Anterior loop. Dark-field slit microscopy of the anterior vitreous in a 76-year-old man demonstrates the anterior loop of vitreous fibers (*arrow*) that traverse from the peripheral retina to the pars plana of the ciliary body. *L* lens (From Sebag and Balazs [20])

over the buckle posterior to the vitreous base, but if the retina is adherent over the buckle because of extensive retinopexy, then the retinotomy is made just posterior to the buckle. The extent of the retinotomy should allow complete relaxation of the inferior retina. An inferior 180° retinotomy is most common. Failure often occurs at the end of the retinotomy, and a 180° retinotomy places the ends more superiorly where there is less risk of re-proliferation and where there is superior tamponade especially with gas. Most relaxing retinotomies are circumferential, but occasionally a radial retinotomy may be indicated in cases of severe posterior foreshortening.

Prophylactic intraocular diathermy is applied to the area that will be cut to prevent bleeding and accumulation underneath the macula. The retina can be cut with scissors, but small incision high-speed vitreous cutters give superior control and safety (Figure V.B.6-4). For a more detailed discussion of the advantages of small incision high-speed vitreous cutters, see chapter V.B.2. Modern vitrectomy cutters. The vitreous can be cut in either a fluid-filled eye or a tamponade-filled eye. The latter is more common in a reoperation. The advantage of cutting in a fluid-filled eye is that traction is more easily evalu-

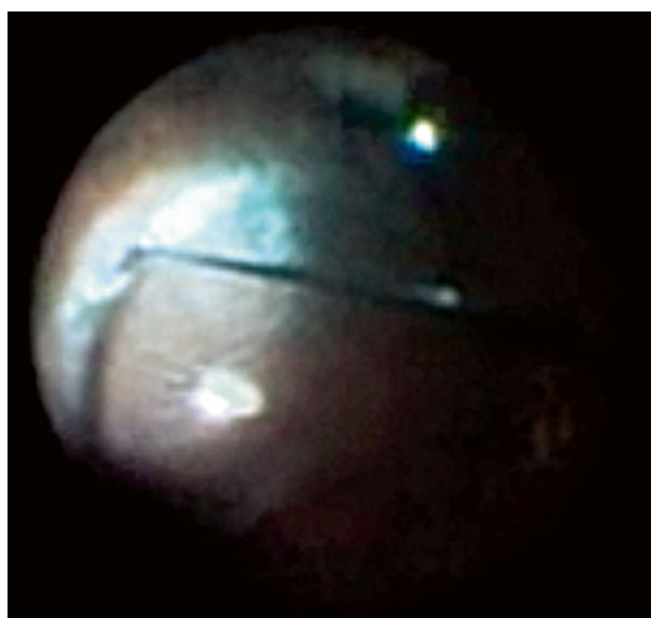

Figure V.B.6-4 Small-gauge vitrector is ideal for cutting the retina (screenshot of retinotomy video) see chapter V.B.5. Management of PVR ated so the proper location and extent of the retinotomy can be optimized. Under oil, the retina can look artificially fine, even though there may be significant traction present. This occult inferior shortening of the retina manifests itself as recurrent retinal detachment after the oil is removed. An advantage of operating through tamponade is that the retina reattaches nicely as the retinotomy is performed, confirming that traction is relieved. However, any bleeding that may occur from inadequate prophylactic diathermy is trapped under the tamponade and requires that the tamponade be removed and the blood washed out. Blood trapped between the oil and retina induces re-proliferation, and the blood trapped between the gas and retina eventually diffuses into the vitreous chamber as the gas absorbs preventing postoperative evaluation of the retina. A successful inferior relaxing retinotomy should have good laser reaction around the margins and minimal fibrous re-proliferation and an attached retina.

B. Vitreous Substitutes

Perfluorocarbon liquid is used to reattach the retina. Laser retinopexy can be administered through the perfluorocarbon liquid or after a subsequent gas-fluid exchange. The view to the periphery through a panoramic viewing system is expanded under gas which facilitates laser retinopexy. A directional laser probe is very useful in lasering the peripheral retinotomy. Laser retinopexy is preferred over cryoretinopexy because it has less effects on the blood-retinal barrier. The perfluorocarbon liquid (Figure V.B.6-5) is then removed and replaced with the final tamponade. Posterior slippage of the posterior edge of the retinotomy can occur at this point of the procedure. This is minimized by removing first all the irrigation fluid anterior to the perfluorocarbon liquid and then removing all subretinal fluid at the edges of the retinotomy before perfluorocarbon liquid posterior to the retinotomy (Figure V.B.6-6) is exchanged for air or oil.

Long-term tamponade can be provided by perfluoropropane gas or silicone oil. Silicone oil may be preferable because it can provide tamponade for several months outlasting the self-limited duration of PVR cellular activity but at the risk of perisilicone oil proliferation. Posterior slippage of the retinotomy which develops during direct exchange of perfluorocarbon liquid for silicone oil is caused by the small amount of infusion fluid trapped anterior to the sclerotomies when perfluorocarbon liquid is infused and the infusion line is open [13] (Figure V.B.6-7). This fluid

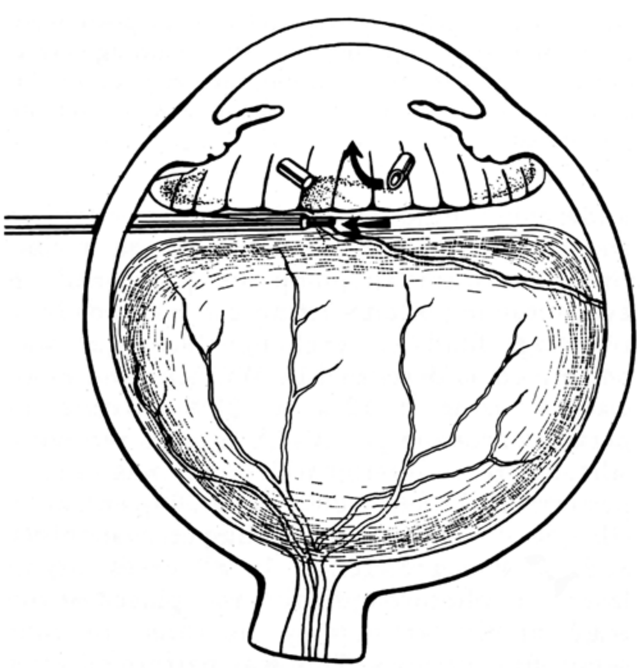

Figure V.B.6-5 Irrigation fluid anterior to the perfluorocarbon liquid bubble is aspirated first (Fig. 1 from page 25 Han et al. [9])

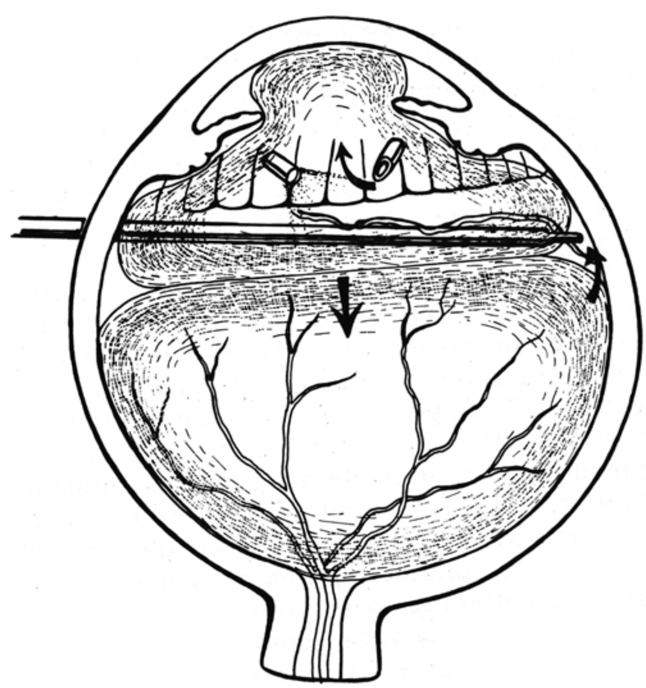

Figure V.B.6-6 After the irrigation fluid anterior to the perfluorocarbon liquid is removed, subretinal fluid at the edge of the retinotomy is meticulously removed before the perfluorocarbon liquid posterior to the retinotomy is exchanged for air or gas (Fig. 3 from page 26 Han et al. [9])

allows the retinotomy edge to slip posteriorly at the conclusion of the oil fill (Figure V.B.6-8). This is avoided by turning off the infusion and then filling the eye completely with perfluorocarbon liquid, pushing any remaining fluid out through a superiorly positioned sclerotomy and making sure the perfluorocarbon liquid is seen in the infusion line. The perfluorocarbon liquid pushes the irrigation fluid anterior to the sclerotomies out through the open infusion

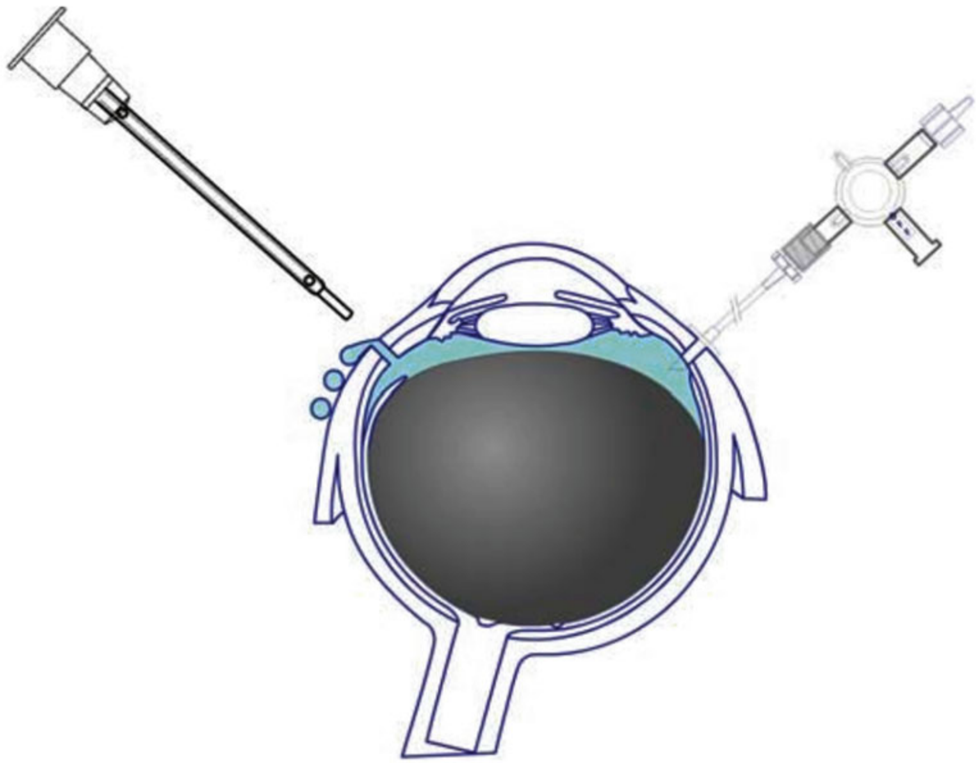

Figure V.B.6-7 Irrigation fluid is trapped anterior to the sclerotomies when perfluorocarbon liquid is injected into the eye and the infusion line is open (Fig. 1 from page 650 Li and Wong [13])

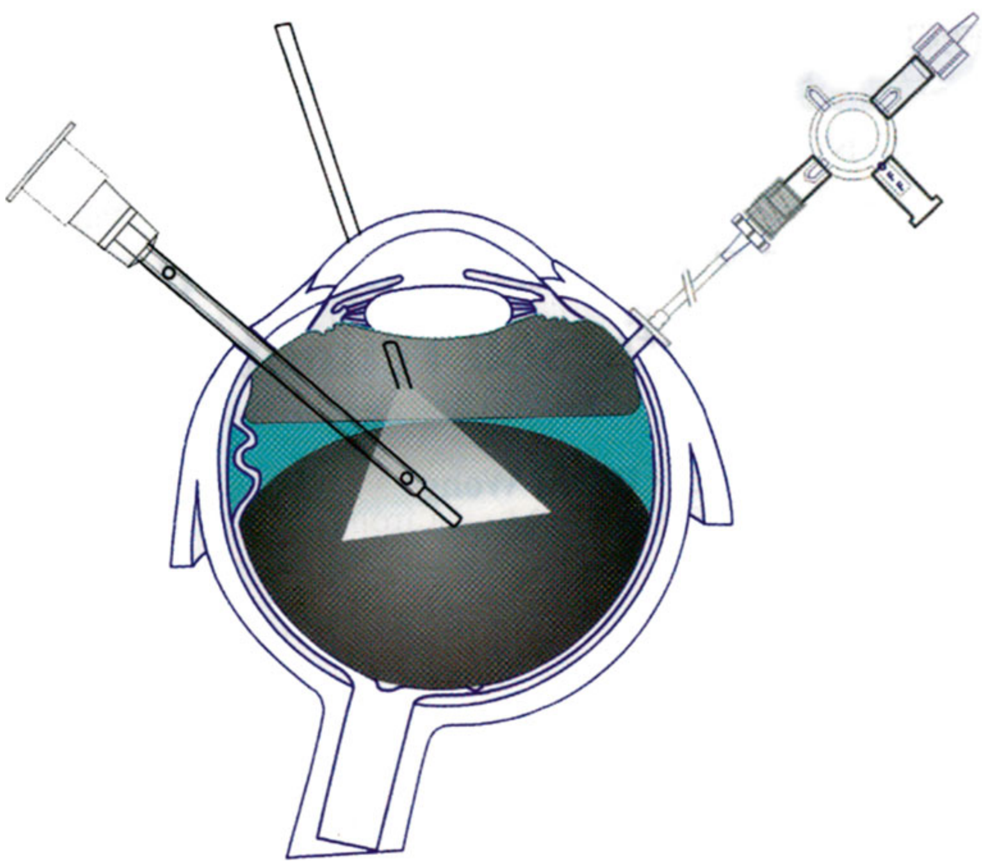

Figure V.B.6-8 The irrigation fluid which was trapped anterior to the sclerotomies, and the perfluorocarbon liquid later causes slippage of the posterior edge of the retinotomy after oil fill (Fig. 2 from page 650 Li and Wong [13]) line (Figure V.B.6-9). Postoperative positioning with oil is minimized when there is a good oil fill. Adequate tamponade with gas because of its diminishing volume may require alternating lateral sides or even a supine positioning. An inadequate gas bubble should be remedied on the first postoperative day by a gas-fluid exchange in the clinic. Oil is removed at 6 months when cellular activity of proliferative vitreoretinopathy is minimal. At the time of oil removal, the retina is examined carefully and prophylactic laser retinopexy or membrane peeling may be indicated (Figure V.B.6-10).

C. Complications

Complications include retained subfoveal perfluorocarbon, macular pucker, hypotony, macular displacement, PVR re-proliferation at the retinotomy edges, corneal decompensation, emulsified silicone oil with or without glaucoma, and iris neovascularization. Retained perfluorocarbon liquid can be aspirated with a 39-gauge cannula [14] or displaced by injection of subretinal fluid and upright positioning. As discussed above, macular pucker is a risk of silicone oil tamponade and is addressed by repeat vitrec-

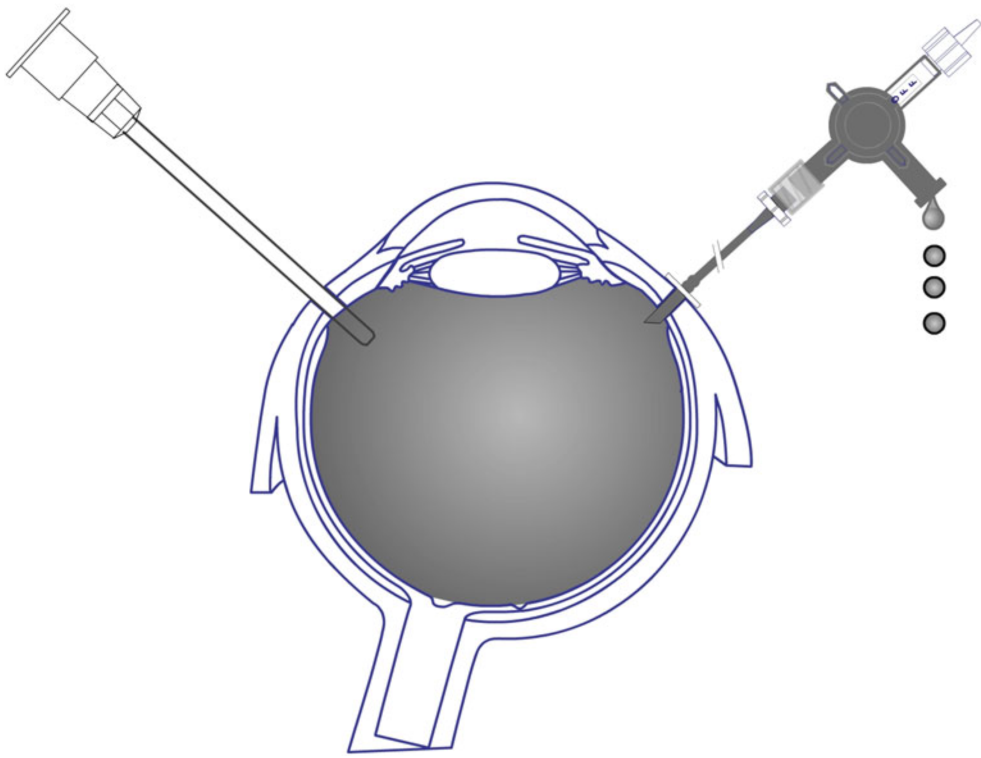

Figure V.B.6-9 To eliminate the trapped irrigation fluid anterior to the sclerotomy, the infusion line is turned off and perfluorocarbon liquid is pushed up the infusion line. At the same time, the trapped fluid simultaneously exits through a superiorly positioned sclerotomy. A total fill of perfluorocarbon liquid is achieved (Fig. 3 from page 650 Li and Wong [13])

Figure V.B.6-10 Successful inferior relaxing retinotomy in an oil-filled eye. There is minimal re-proliferation at the retinotomy margins. The secondary macular pucker will be peeled at the time of oil removal (Courtesy of VMR Institute for Vitreous Macula Retina, Huntington Beach, California) tomy and membrane peeling. Internal limiting membrane peeling may prevent recurrences. Corneal decompensation is caused by oil migrating into the anterior chamber [15, 16]. Decreased aqueous production caused by PVR fibrosis of the ciliary body also contributes to corneal decompensation [17]. Emulsified oil, previously thought to be due to impurities in the oil, is now thought to be caused by emulsifiers in the oil such as blood and protein [18]. Therefore, preventing hemorrhage during retinotomy is important. Iris neovascularization is caused by fibrotic organization within the ciliary body and pars plana, and removal of the retina anterior to the retinotomy prevents this and consequent hypotony.

IV. Future Developments

A. Surgical

Twenty-seven-gauge vitrectomy instrumentation may be ideal for performing relaxing retinotomy. The inefficiency of such small-gauge instrumentation does not matter since the vitreous has already been removed. On the other hand, the precision and ability of the cutting port to be closer to the retinal pigment epithelium during the retinotomy should be an advantage [19]. There are significant challenges to the application of femtosecond laser to the posterior segment compared to its use in the anterior segment. However, the photodisruptive properties of femtosecond laser could be harnessed for the cutting of the retina [see chapter V.B.3. Future vitrectomy technologies].

B. Pharmacologic

Pharmacologic vitreolysis [see chapter VI.A. Pharmacologic vitreolysis] may provide useful adjuncts to surgery of anterior PVR by weakening the very strong vitreoretinal adhesion at the vitreous base. Indeed, studies in monkeys employing chondroitinase to perform pharmacologic vitreolysis found disinsertion of the vitreous base [see chapter VI.H. Chondroitinase as a vitreous interfactant – vitreous disinsertion in the human].

Abbreviations

PVR	proliferative vitreoretinopathy
ILM	inner limiting membrane
L	lens

References

1. Lewis H, Aaberg TM. Anterior proliferative vitreoretinopathy. Am J Ophthalmol. 1988;105:277–84.
2. Machemer R, Aaberg TM, Freeman HJM, et al. Updated classification of retinal detachment with proliferative vitreoretinopathy. Am J Ophthalmol. 1991;112:159–65.
3. Machemer R. Retinotomy. Am J Ophthalmol. 1981;92(6):768–74.
4. Zivojnovic R. Silicone Oil in Vitreo-retinal Surgery. Dardrecht: Martinus Nidjhoff Publishers; 1967. p. 142–3.
5. Han D, et al. Relaxing retinotomy and retinectomy: surgical results and predeterming visual outcomes. Arch Ophthalmol. 1990;108(5):694–7.
6. Morse L, McCuen BM, Machemer R. Relaxing retinotomy: analysis of anatomic and visual results. Ophthalmology. 1990;97(5):643–7.
7. Iverson DA, et al. Indications and results of relaxing retinotomy. Ophthalmology. 1990;97(10):1298–304.
8. Federman J, Eagle R. Extensive peripheral retinectomy combined with posterior 360 degree retinotomy for retinal reattachment in advanced proliferative vitreoretinopathy. Ophthalmology. 1990;97(10):1305–20.
9. Han DP, et al. Management of complex retinal detachment with combined relaxing retinotomy and intravitreal perfluoro-n-octane injection. Am J Ophthalmol. 1994;118(1):24–32.
10. Blumenkrantz M, et al. Relaxing retinotomy with silicone oil or long acting gas with severe proliferative vitreo retinopathy: Silicone Study report 5. The Silicone Study Group. Am J Ophthalmol. 1993;116(5):557–64.
11. Hogan MJ. The vitreous. Its structure in relation to the ciliary body and retina. Invest Ophthalmol. 1963;2:418–45.
12. Daicker B. Sind die symptom “Weiss mit Druck” und “Weiss ohne Druck” durch die periphere netzhautsklerose bedingt? Mod Probl Ophthalmol. 1975;15:82–90.
13. Li KK, Wong D. Avoiding retinal slippage during macular translocation surgery with 360 retinotomy. Graefes Arch Clin Exp Ophthalmol. 2008;246:649–51.
14. Roth DB, Sears JE, Lewis H. Removal of retained subfoveal perfluoro-n-octane liquid. Am J Ophthalmol. 2004;138(2):287–9.
15. Liesenhoff HH, Schmitt J. Koplikationene durch flussiges silicon in der vorderkammer. Berl Dtsch Ophthalmol Ges. 1969;69:643–4.
16. Sternberg Jr P, Hatchell DL, Foulks GN, et al. The effect of silicone oil on the cornea. Arch Ophthalmol. 1985;103:90–4.
17. Zarbin MA, Michels RG, Green WR. Dissection of epiciliary tissue to treat chronic hypotony after surgery for retinal detachment with proliferative vitreoretinopathy. Retina. 1991;11:208–13.
18. Bartov E, Pennarola F, Savion N, et al. A quantitative in vitro model for silicone oil emulsification. Role of blood constituents. Retina. 1992;12:523–7.
19. Oshima Y, Wakabayashi T, Sato T, Ohji M, Tano Y. A 27-gauge instrument system for transconjunctival sutureless microincision vitrectomy surgery. Ophthalmology. 2010;117:93–102.
20. Sebag J, Balazs EA. Pathogenesis of CME – an anatomic consideration of vitreoretinal adhesions. Surv Ophthalmol. 1984;28(Suppl):493–8.