

Retina 2003 Contents

Program Directors' Welcome Letter ii

Faculty Listing iv

Program Schedule xii

Section I: Retinal Detachments and Vitreous Surgery 1

Section II: Intravitreal Steroids in Retinal Diseases 57

Section III: Diabetic Retinopathy and Retinal Vascular Diseases 87

Section IV: Inherited Diseases and Ocular Oncology 133

Section V: Retinal Imaging 163

Section VI: Clinical Trials and Practical Applications 181

Section VII: Age-Related Macular Degeneration: Surgical Therapy 241

Section VIII: Instrumentation and Devices: Part 1 271

Section VIII: Instrumentation and Devices: Part 2 289

Section IX: Pediatric Retinal Diseases 313

Section X: Artificial Vision Update: The Global Experience 339

Section XI: Uveitis, Trauma, and Infectious Disease 359

Resources for Individuals with Visual Impairment 380

Faculty Financial Disclosure 386

Presenter Index 390

Managing the Severe High Myope with Retinal Detachment

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I. Introduction

- A. The incidence of severe high myopia (-6 D or more or with axial length > 26 mm) differs in the general population around the world. The prevalence of degenerative high myopia varies from 0.2% to 9.6%,¹ being greatest in Asians.
- B. High myopia is associated with increased incidence of retinal detachment with a wide entity of retinal pathology and tears, ranging from holes in the lattice, atrophic holes, and horseshoe tears to giant retinal tears and macular holes. Pierro et al² reported that the prevalence of retinal tear and hole among patients with high myopia was 12.1%.
- C. Lattice degeneration occurs more frequently among myopic than nonmyopic eyes and contributes to the tendency of retinal detachment to develop in myopic eyes. Highest incidence of lattice degeneration in myopes was found with an axial length of 29–30 mm (> 15 D).³ Lattice patients with high degrees of myopia show high risk of detachment during their life, caused by atrophic holes. This is in contrast to moderate myopes with lattice, who tend to develop tractional tears caused by premature posterior vitreous detachment⁴ (due to early syneresis and increased axial length of the eye). Thus both vitreous modification and peripheral fundus abnormalities in high myopic eyes are major factors predisposing to retinal

detachment. Bonnet⁵ specified atrophic holes in lattice and para vascular retinal tears in myopic retinal detachments, and Malbran⁶ showed in another series equatorial breaks in 38%.

II. Management of Retinal Detachment in Severe High Myopic Eyes

Surgical option of this specific type of rhegmatogenous detachment include:

A. Scleral buckling

This is a successful method of closing rhegmatogenous breaks in high myopes. Circumferential buckling can support the ora up to equator, lattice, and tears, with a favorable anatomical success rate. Kwork⁷ reported an 86.1% success rate in treating retinal detachment in high myope with scleral buckling.

Difficulties and problems in scleral buckling procedure in high myope retinal detachment included⁸⁻¹⁰

1. Thin sclera, scleral ectasia
2. Choroidal hemorrhage, choroidal detachment
3. Hypotony
4. Posteriorly located breaks
5. Myopic shift equivalent to 1–3 diopters.

B. Vitrectomy \pm buckle

Vitrectomy relieves direct traction on retinal breaks by detaching the hyaloid and removing vitreous gel and attach-

Retinal Detachments and Vitreous Surgery

ments on breaks as well as vitreous base. Further use of encircling band at the equator can be helpful, even in conjunction with circumferential buckle, to support residual vitreous base.

Advantages:

1. Direct relief of traction on break.
2. Bypass problems of thin sclera
3. Dealing with posterior pole-associated problems such as posterior staphyloma, posterior breaks, macular holes, macular schisis

4. Dealing with giant retinal breaks (GRB)

5. Retinal detachment associated with proliferative vitreoretinopathy (PVR)

6. Patients with recent refractive procedure, as it does not increase axial length so there is no effect on postoperative refraction. Also better for recent corneal flap in patients with recent LASIK procedure.

C. Pneumoretinopexy

Suitable for selected cases with small superior retinal breaks without traction.

Table 1. Clinical Characteristics of Retinal Detachments

Characteristics	No. of eyes (%)
<i>Number of quadrants</i>	
1	12 (2.46%)
2	22 (4.52%)
3	129 (26.54%)
4	323 (66.46%)
Macular involvement	471 (96.91%)
<i>Types of retinal breaks</i>	
Tractional horseshoe tears	73 (15.02%)
Atrophic holes in lattice	157 (32.30%)
Tractional and atrophic	212 (43.62%)
Giant retinal tears	44 (9.05%)
<i>Number of retinal breaks</i>	
1	143 (29.42%)
2	167 (34.26%)
3	101 (20.78%)
4 or more	42 (15.43%)
<i>Location of breaks in relation to equator</i>	
Equator	26 (5.34%)
Anterior to equator	369 (75.92%)
Posterior to equator	37 (7.61%)
Anterior and posterior to equator	54 (11.11%)
Presence of posterior staphyloma	174 (35.80%)

An advantage to this technique is that there is no alteration in ocular shape or length compared to buckling procedure, so pneumoretinopexy is preferred in suitable selected cases having retinal detachment and patients with recent refractive procedure with early superior retinal tears.¹¹

III. Experience with 486 Cases

A. We reviewed charts of 486 cases of severe myopic patients with rhegmatogenous retinal detachment and peripheral breaks (operated upon over 4 years from 1999 to 2002). Eighty-seven (87) other cases were excluded as they had associated myopic macular holes. All patients had ≥ 8 diopters of myopia (range = 8 D to -24 D) with an axial length range from 26.5 mm to 35.4 mm. Characteristics of their retinal detachment are summarized in Table 1.

B. Choice of management and results (see Table 2)

1. Scleral buckling was performed for 139 eyes (29.60% of the total 486 eyes). Circumferential or segmental

buckling + encircling band was used in 97 eyes (69.78%) and encircling tire with band was used in 42 eyes (30.21%). An associated radial buckle was needed also in 16 eyes (11.54%). Drainage of subretinal fluid was needed for 117 (84.17%), and sulfur hexafluoride (SF₆) gas was injected in 29 (20.86%). This group showed an anatomical success rate for retinal reattachment of 117 eyes (85.61%) after 1 procedure; 22 eyes (15.82%) needed a second surgery. Visual improvement of 2 or more lines was seen in 108 eyes (77.97%) with retinal attachment with at least 6 months of follow-up.

2. Pars plana vitrectomy was performed in 335 eyes (68.93%), and an additional scleral buckling was used in 265 out of 335 eyes (78.50%), mostly 42 encircling exoplane. Perfluorocarbon liquid (PFC) was used to drain subretinal fluid and reposit the retina in 221 (65.97%), mainly for those with giant retinal breaks (GRBs) and those with posterior staphylomas. PFC liquids were used

Table 2. Surgical Choices of Procedures Used

	Scleral Buckling (SB) (n = 139)(28.60%)	Vitrectomy (n = 335)(68.93%)	Pneumatic retinopexy (n = 12)(2.46%)
Encircling band + circumferential or segmental tire	97(69.68%)		
Encircling tire	42 (30.21%)		
Associated radial implant	16 (11.51 %)		
Vitrectomy + gas		72 (14.81%)	
Vitrectomy + SB + tamponade		263 (78.50 %)	
<i>Anatomic outcome (retinal reattachment)</i>			
One surgery	117 (85.71%)	317 (94.62 %)	11 (91.66 %)
Needed a second surgery	22 (15.82 %)	18 (5.37 %)	1 (8.33 %)
<i>Final visual outcome in reattachment retina</i>			
> 2 lines of visual acuity	108 (77.91 %)	316 (94.32%)	9 (75%)

to displace subretinal fluid out of posterior staphylomas and drape the retina into the staphylomas as well as stabilize the retina while membrane peeling (if present) over the posterior pole. SF₆ was used in 301 eyes (89.85%), while silicone was the primary tamponade in 34 eyes (10.14%) and was used in 22 eyes as a reoperative tamponade.

The anatomical success rate in the PPV group was 317 eyes (94.62%) with 1 operation; 18 eyes (5.37%) needed reintervention. Visual improvement of 2 or more lines was achieved in 316 eyes (94.32%) over at least 6 months of follow-up.

3. Only 12 eyes (2.46%) were treated with pneumatic retinopexy; 0.3 ml of 100% C₃F₈ and cryotherapy. In this group, 11 retinas (91.66%) were reattached in 1 procedure; the remaining eye (8.31%) needed a scleral buckling operation. Nine eyes (75%) showed 2 or more lines of visual improvement.

IV. Discussion

Myopic eyes tend to develop lattice degeneration, retinal breaks, and retinal detachment.¹ The risk of retinal detachment is elevated 4 times in eyes with -1 D to -3 D of myopia compared to emmetropic individuals, and up to 10 times in eyes with more than 3 D spherical equivalent myopia.¹² This study highlighted several important characteristics of retinal detachment in severe high myopic patients. Retinal detachment was complete in 66.46% of eyes, with macular involvement in 96.9% of eyes presenting with detachment. Tears, atrophic holes, or both in nearly 91% of eyes caused retinal detachment.

Vitreoretinal surgery offers us the choice of treating this problem. Certainly this

problem has its own characteristics when speaking of severe high myopes with very high axial length as thin sclera, risk of hemorrhage, extensive chorioretinal degeneration, poor chorioretinal uptake when doing retinopexy, and the presence of posterior staphyloma.

In this study scleral buckling offered a good modality of treatment for such a condition, with a success rate of 85.71%. Drainage of subretinal fluid was needed in 84.7% of patients, especially those with extensive chorioretinal degeneration, poor retinal pigment, epithelial pump, and associated difficulty of localizing retinal breaks.

A shift toward pars plana vitrectomy (PPV) with scleral buckling was noticed in this study, offering better anatomical results. PPV with wide-angle viewing and scleral indentation facilitated tear localization and removed direct traction and treatment of both anterior and postequatorial breaks, as well as treating GRBs. Patients with posterior staphyloma were better managed with PPV and buckle, as it facilitates removal of the posterior hyaloid and posterior epiretinal membranes to allow posterior retina to reconfont into the staphyloma (36% in this study). So associated pole problems including foveal schisis and foveal detachment over a staphyloma are solved though PPV.¹³⁻¹⁴

PPV also offered less effect on final axial length and refraction of the patient, especially those who underwent refractive procedure, where buckling is to be avoided to prevent myopic shift.¹⁵ PPV offers also larger volume of tamponade when needed, which is a must in some cases such as those involving large breaks or extensive areas of chorioretinal degeneration. Silicone oil was needed in most cases associated with GRBs and deep posterior staphylomas.

Finally, although pneumatic retinopexy was used in only a small number of

patients (2.46%), it was effective and offered a treatment modality for selected patients with no effect on postoperative spherical equivalent. This is a good option for patients after refractive procedures such as LASIK. So with modern vitreoretinal surgical procedures, problems of severe myopic retinal detachment can be solved with good anatomic and functional results. Proper choice and selection of treatment modality is important in the management.

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Managing "Bad" Stage 3 Retinopathy of Prematurity

Michael T. Trese MD

Definition of "Bad" Stage 3 Disease (Vascularly Active Eye)

"Bad" Stage 3 retinopathy of prematurity (ROP) is defined as disease that presents in Zone I or posterior Zone II with areas of flat neovascularization and plus disease or at an early postmenstrual age.

Examiner Needs to Be Able to Distinguish:

- A. Typical Stage 3 from flat Stage 3
- B. Proper zoning
- C. Child's postmenstrual age
- D. Naked shunt vessels
- E. Racial/genetic characteristics

ROP as Self-Limiting

ROP is a self-limiting retinal vascular disease that can lead to effusive and tractional retinal detachment and blindness. It is self-limited by endogenous TGFB2 that occurs at the due date.

"Bad" Stage 3 ROP

Certain forms of vascular changes are more likely to lead to retinal detachment than others. Posterior disease that occurs earlier than 37 weeks postmenstrual age is more likely to cause retinal detachment.

Treatment of "Bad" Stage 3 ROP

- A. Cryo treatment of posterior ROP, usually due to the large area needed to be treated, requires open cryo and causes a large effusion that often makes things worse.

- B. Until drug therapy is available, laser treatment is the best choice (diode red is preferred to argon green, as in vascularly active eyes the tunica vasculosa lentis may be present.) The goal is to treat all areas of the avascular retina in these eyes.

C. Common misconceptions

- 1. In eyes with flat Stage 3 disease, no ridge tissue. The area of the retina beneath the flat neovascularization is avascular retina and needs treatment.
- 2. Fear of treating posterior due to the macular development. There is often a temporal avascular notch that should be treated.

- D. Evolution of flat neovascularization to retinal detachment.

- E. Management of tractional components is by vitrectomy techniques (lens-sparing).

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Screening for Retinopathy of Prematurity and Risk Management

Philip J Ferrone MD

I. Complete Knowledge of Retinopathy of Prematurity (ROP)

A. Able to easily recognize all stages of disease, including normal immature retina and variants of disease

1. Immature developing normal retina

- a. Normal choroidal pattern: Not fully vascularized
- b. Junction of vascularized and non-vascularized retina

2. Stage 1: Demarcation line

3. Stage 2: Ridge

4. Stage 3: Neovascular (NV) ridge

- a. Brushborder NV ridge
- b. Elevated NV ridge
- c. Flat NV ridge
- d. Regressed, popcorn NV

5. Stage 4: Partial retinal detachment (RD)

- a. Stage 4A retinal detachment: Fovea attached
- b. Stage 4B retinal detachment: Fovea detached

6. Stage 5: Total retinal detachment

- a. Open funnel total retinal detachment
- b. Closed funnel total retinal detachment @ leukocoria

7. Plus disease: Vascular dilation and tortuosity

- a. Normal infant retinal vessels (thin, wire-like, no tortuosity)
- b. Mild plus disease
- c. Moderate plus disease
- d. Marked plus disease

B. Zones of disease

- 1. Zone I: Circle with a radius of 30 degrees centered on optic nerve head (any part of ridge within view of 28 diopter indirect lens)
- 2. Zone II: From Zone I temporally to the temporal equator and to the ora serrata nasally
- 3. Zone III: From Zone II temporally to the ora serrata temporally

C. Clock hour involvement: 0 through 12 clock hours involved (for use with Stages 1 through 4)

D. Difference in view of ROP from reference pictures

- 1. American Academy of Ophthalmology (AAO) standard Kowa camera views of disease states → High magnification
- 2. Standard indirect ophthalmoscope view with a 28 diopter lens → Standard (medium) magnification
- 3. Retcam (130 degree) ROP lens view → Lower magnification, wide field view

E. Factors hampering view of disease

1. Baby looking away
 - a. Alphonso lid speculum useful
 - b. Flynn scleral depressor useful
2. Poor dilation
 - a. ? Due to baby squeezing dilating drops out
 - b. ? Due to advanced plus disease not allowing for good dilation
3. Mildly hazy, normal premature cornea: Naturally occurring early in life in some very premature infants
4. Persistent tunica vasculosa lentis (TVL) in premature babies
 - a. Due naturally to early postconceptional age (PCA)
 - b. Due to abnormal blood vessel activity (plus disease)
5. Flare in the vitreous cavity: Due to breakdown of the blood-ocular barrier, usually associated with advanced plus disease
6. Vitreous hemorrhage
 - a. Due to advanced ROP
 - b. Due to birth trauma

F. Pre-threshold disease

1. Any Zone I ROP
2. Zone II ROP, Stage 3, without plus disease
3. Zone II ROP, Stage 2, with plus disease
4. Zone II ROP, Stage 3 (less than threshold clock hours), with plus disease

G. Threshold disease

1. Zone I or II ROP, Stage 3 (5 contiguous clock hours), with plus disease

2. Zone I or II ROP, Stage 3 (8 cumulative clock hours), with plus disease
3. With posterior disease (Zone I, or border Zone I/Zone II), be aware of *flat* Stage 3 that may be difficult to detect

H. Retinal detachment (Stage 4)

1. Early
 - a. Evolving traction on NV
 - b. Dragging of retinal vessels/ macula
2. Late
 - a. Loss of choroidal vascular pattern on indirect ophthalmoscope viewing
 - b. Peripheral "white retina" sign due to double thickness dragged retina

I. Danger signs associated with aggressive disease

1. Very low birth weight (BW) baby, < 1000 grams (g)
2. Early onset of disease
3. Posterior disease
4. Rapid tempo of disease progression
5. Marked vascular activity with a significant TVL

II. Screening Recommendations for Babies at Risk for ROP

- A. Initial eye exam at 31 weeks postconceptional age or 4 weeks chronological age (whichever is later)
 1. BW < 1500 g, or
 2. Gestational age (GA) < 28 weeks, or
 3. Selected babies with a BW between 1500 g and 2000 g with an unstable clinical course
- B. Adequate pupillary dilation with indirect ophthalmoscopy
- C. At least 2 exams to detect ROP

D. Exam timing should allow for sufficient time to treat plus extra time if transferring the baby is necessary

E. Follow-up examinations: Based on findings at the previous exam

1. Pre-threshold disease → 1 week follow-up
 - a. Zone I ROP (not yet threshold)
 - b. Zone II ROP, Stage 3, without plus disease
 - c. Zone II ROP, Stage 2, with plus disease
 - d. Zone II ROP, Stage 3 (less than threshold clock hours), with plus disease
2. Zone I, without ROP → 1 to 2 weeks follow-up
3. Less severe ROP in Zone II → 2 weeks follow-up
4. Immature, Zone II, no plus disease → 2 to 3 weeks follow-up

F. Acute phase ROP screening can be discontinued when the risk of ROP visual loss is minimal or passed when:

1. Fully mature retinal vasculature (to the ora serrata nasally or within 1 disc diameter from the ora serrata temporally) is present
2. 45 weeks PCA is reached without the infant having previously developed pre-threshold ROP or worse
3. Progression of normal retinal vessels into Zone III, *without* prior Zone II ROP

III. Threshold Disease

A. Definition:

1. > 5 contiguous clock hours of Stage 3, with plus disease
2. 8 total clock hours of Stage 3, with plus disease

B. Treat within 72 hours

C. Diode laser: Complications include:

1. Risk of progression of disease
2. Cataract
3. Vitreous hemorrhage
4. Retinal detachment
5. Anterior segment ischemia
6. Blindness

D. Follow-up 1 week post laser treatment

E. If plus disease persists at 2 weeks post laser treatment, consider repeating laser treatment.

F. Look for development of retinal detachment (occurs most commonly at 38 to 45 weeks PCA).

G. Once RD develops, it can progress rapidly (ie, over a few weeks to advanced stages).

H. If RD develops, then treat (with laser vs scleral buckle vs vitrectomy) or refer promptly.

IV. Medicolegal Issues

- A. From the outset of an interaction with a patient, keep the parents informed of the nature and possible severity (blindness) of ROP. Ideally give a prepared handout from the AAO or Ophthalmic Mutual Insurance Company (OMIC).
- B. Keep parents informed of progression of the condition during the course of follow-up and treatment.
- C. Emphasize to parents the need for prompt and close follow-up after hospitalization, and point out the risk of irreversible blindness if this is not adhered to (ie, missed appointments).
- D. Document all findings and discussions completely and well in the patient's record.

The Debate: Stage 4 Retinopathy of Prematurity—The Scleral Buckle

Eric R Holz MD

I. Options

- A. Observation
- B. Scleral buckle (SB)
- C. Lens-sparing vitrectomy (LSV)
- D. Lens-sparing vitrectomy + scleral buckle (LSV/SB)
- E. Vitrectomy + lensectomy (PPV/PPL)
- F. Open sky vitrectomy

II. Technique

- A. EUA, treat "skip" areas
- B. Mark ridge externally
- C. Place #240 band explant
- D. #270 sleeve *always* SN quadrant
- E. Pediatric ophthalmologist consult 2–4 weeks (refraction, patching)
- F. Section buckle (not removal) at 3–6 months

III. SB Anatomic Success (60%–75%): Selected Case Series

- A. McPherson, Hittner (*Ophthalmology*, 1979)
 - 1. Stages 4A, 4B, 5
 - 2. 6/10 (60%) attached
 - 3. 360° 3mm sponge ± DSRF
 - 4. ERG severely extinguished/non-recordable: 6/6
- B. Greven, Tasman (*Ophthalmology*, 1990)

- 1. Stage 4B, 5 (19/22)
- 2. 13/22 (59%) attached
- 3. Lamellar bed, 360° support, + DSRF
- 4. 4/10 (40%) ≥ 20/400

C. Trese (*Ophthalmology*, 1994)

- 1. 70 eyes, Stages 4A, 4B, 5 – predominantly exudative
- 2. Attached
 - a. 12/17 (70%): 4A
 - b. 29/43 (67%): 4B
 - c. 4/10 (40%): 5
- 3. #240 band (+507G if RRD) Ø DSRF if no break

D. Hinz, de Juan, Repka (*Ophthalmology*, 1998)

- 1. Stage 4A
- 2. 6/8 (75%) attached
- 3. 360° 2.5mm silicone band explant Ø DSRF

IV. LSV Anatomic Success (70%–94%)

- A. Capone, Trese (*Ophthalmology*, 2001): 36/40 (90%)
- B. Moshfeghi, Banach, Salam, Ferrone (*Int Ophthalmol Vis Sci*, 2003): 30/32 (94%)
- C. Daccache, Maguluri, Thompson, Hartnett (*Int Ophthalmol Vis Sci*, 2003): 7/10 (70%)

Pediatric Retinal Diseases

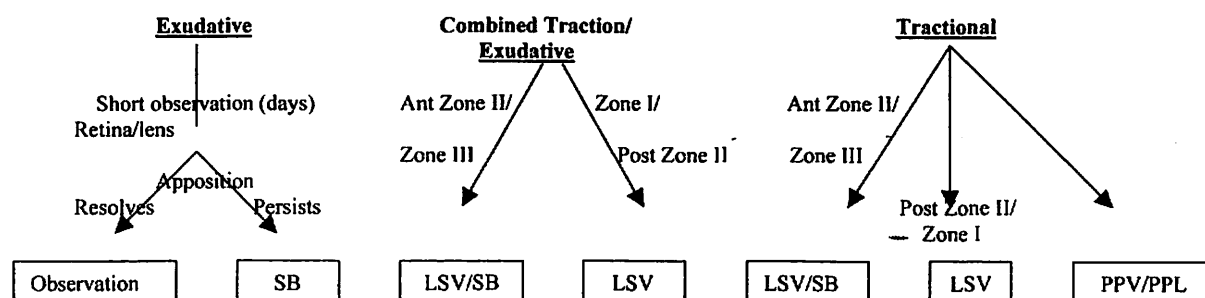


Figure 1. ROP Retinal Detachment

D. Cherwek, O'Keefe, Burian, Hubbard
(*Int Ophthalmol Vis Sci*, 2003): 23/28
(82%)

V. LSV/SB Anatomic Success

Chandran, Worrall, Sun, Mieler, Holz (*Int Ophthalmol Vis Sci*, 2002): 15/16 (94%)

VI. Advantages of SB

A. Avoid iatrogenic retinal breaks

B. Avoid iatrogenic cataract

1. Ferrone, Harrison, Trese (*Ophthalmology*, 1997): 13/85 (15%)
2. Moshfeghi, Banach, Salam, Ferrone (*Int Ophthalmol Vis Sci*, 2003): 2/32 (6%)
3. Cherwek, O'Keefe, Burian, Hubbard (*Int Ophthalmol Vis Sci*, 2003): 0/28 (0%)

C. Technically easier for OR staff, surgeon

VII. Disadvantages of SB

A. Induced anisometropia: Chow, Ferrone, Treses (*Arch Ophthalmol*, 1998)

1. 7 eyes S/P SB for stage 4
2. Mean anisometropia -9.5 D, mean refractive error -11 D
3. SB division (average 36 weeks) -5.68 D

B. Induced strabismus

1. Snir, Nissenkorn, Sherf, Cohen (*Ann Ophthalmol*, 1988)

- a. 187 eyes, compared premature to ROP
- b. Strabismus 23% ROP vs 9% control

2. Cryotherapy for Retinopathy of Prematurity Cooperative Group (*Arch Ophthalmol*, 1998): 289/2449 (11.8%) strabismus at 1 year

3. Ricci, Santo, Ricci, Minicucci, Molle (*Graefes Arch Clin Exp Ophthalmol*, 1996)

- a. 28 eyes, stage 4
- b. 13/28 (46%) attached
- c. 12/13 (92%) strabismus

C. Required second procedure

D. Cannot address posterior (zone 1/posterior zone II) traction

E. May not permanently relieve traction

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The Debate: Stage 4 Vitreoretinal Retinopathy of Prematurity—The Lens-Sparing Vitrectomy

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Introduction

Although retinal ablation is effective in a majority of cases of threshold retinopathy of prematurity (ROP), a significant number of these eyes progress to retinal detachment. The risk of life-long visual compromise is significantly greater once retinal detachment develops.

The advanced stages of ROP (Stages 4A, 4B, and 5) are poorly understood. Common misconceptions are that macula-sparing (Stage 4A) partial retinal detachments are largely benign, that surgery should be deferred until the macula is detached, that scleral buckle is the preferred retinal reattachment procedure, and that useful vision cannot be obtained in eyes with advanced (Stage 4B or Stage 5) retinal detachment. Thus it is important to understand the goal of surgery relative to the severity of the detachment in such eyes. Proper timing is also critical.

Surgical Goals

The goal of intervention for ROP-related retinal detachments varies with the severity of the detachment:

- Stage 4A: The goal for extramacular retinal detachment (Stage 4A ROP) is an undistorted or minimally distorted posterior pole, total retinal reattachment, and preservation of the lens and central fixation vision.
- Stage 4B: Surgery for tractional retinal detachments involving the macula (Stage 4B ROP) is performed to minimize retinal distortion and prevent total detachment (Stage 5). The practical surgical goal is to reattach as much of the retina as is possible. Partial residual retinal detachment in such eyes is com-

mon. The functional goal for Stage 4B eyes is ambulatory vision.

- Stage 5: The surgical goal is to reattach as much of the retina as possible. As with Stage 4B detachments, partial residual retinal detachment is common. Form vision may be preserved following vitrectomy for Stage 5 ROP.^{1,2}

Timing of Surgery

ROP-related detachments may appear stable in the first few weeks or months after peripheral retinal ablation. Yet neither the stability of partial detachment nor visual acuity is predictable from retinal appearance in infants with ROP. This is particularly true for untreated eyes or those with incomplete peripheral retinal ablation. Visual outcome of eyes with even partial ROP-related retinal detachment is generally poor by 4.5 years of age: in the Cryo-ROP study cohort of 61 eyes with partial RD 3 months after threshold, only 6 eyes had vision of 20/200 or better at age 4.5.^{3,4}

Thus, ROP-related retinal detachments progress, often very gradually, for years. In general, the earlier the surgical intervention, the better, as the prognosis for vision is best when the detachment is least extensive. In eyes with Stage 4 detachments and thorough peripheral retinal ablation, surgery is typically done between 38 and 42 weeks postconceptional age.⁵

The exception to this rule is when an eye is highly vascularly active. In the setting of Stage 4 retinal detachment in a highly vascularly active eye with marked "plus disease" without prior peripheral retinal laser ablation, it is often best to treat the avascular peripheral retina first; the risk of uncontrollable bleeding is much greater in vascularly

Pediatric Retinal Diseases

active eyes. If the eye has a Stage 5 retinal detachment with significant vascular activity, one may need to wait several weeks for the vascular activity to quiet.

Surgical Anatomy

Considered as simply as possible, detachment is typically tractional, originating at the ridge. However, the configuration and severity of ROP-related retinal detachments depends on the relative contribution of proliferative tissue along several planes. Understanding each of these proliferative planes is important for optimal surgical repair:

- **Intrinsic to retina:** Consists of proliferation intrinsic to the ridge itself. It is the tractional vector not removable surgically. Contraction of this circumferential vector results in a radial fold. It can be addressed by scleral buckle alone when it is the sole tractional vector located near or anterior to the equator.
- **Ridge-to-lens:** The most common and easily conceptualized traction vector, and the most important to interrupt surgically, often extending circumferentially from the ridge toward the mid-peripheral lens.
- **Ridge-to-ridge:** Extends as a sheet across the "mouth" of the developing funnel-shaped retinal detachment.
- **Ridge-to-ciliary body:** Extends from the ridge anteriorly toward the ciliary body.
- **Ridge-to-retina:** Extends from the elevated ridge back toward the portion of the retina anterior to the original location of the ridge.
- **Disk stalk:** There are 3 variants of the proliferative tissue extending from the optic disk:
 - Epiretinal sheet extending along the retinal surface for the short distance to the ridge. Adherent to the retina. Usually seen in eyes with a ridge located very posterior to the equator.
 - Transvitreally to the ridge. Usually seen in eyes with an equatorial ridge.
 - Transvitreally to the ridge-to-ridge sheet. Usually seen in eyes with a ridge located anterior to the equator.

Surgical Approach

Though scleral buckling^{6,7} and vitrectomy^{8,9} have both been used to manage Stage 4A ROP, vitreous surgery is most effective for interrupting progression of ROP from Stage 4A to Stages 4B or 5 by directly addressing transvitreal traction resulting from fibrous proliferation.¹⁰ Disadvantages of scleral buckling for Stage 4A ROP are the dramatic anisometropic myopia and the second intervention required for transection or removal so that the eye may continue to grow.¹¹

Scleral buckle

For all these reasons, we rarely perform scleral buckle for ROP-related retinal detachment. However, if one is not facile with vitrectomy for such eyes, scleral buckle may be the preferred alternative approach, particularly for bilateral detachment. The element of choice for scleral buckle in infants is a #40 silicone band. The band is placed to support the ridge as one would support a retinal tear, with the encircling element supporting the ridge along the anterior portion of the element. The buckle is placed along the greater curvature of the eye in order to minimize migration of the band, which occurs commonly in infants. Sutures are imbricated to provide height. The anterior chamber is tapped with a 30-gauge needle to normalize intraocular pressure.

Lens sparing vitrectomy

If vitreoretinal pathology is accessible (ie, the lens and retrolenticular vitreous are not involved) the lens may be spared. This is our preferred approach for Stage 4A and many Stage 4B detachments. Lens-sparing vitreoretinal surgery is uniquely suited to the management of such eyes. Maguire and Trese reported the technique initially for eyes with subtotal posterior retinal detachment involving the macula.¹²

An infusion light pipe or pic, vitreous cutter, and MPC scissors are employed in the procedure. The eye is entered through the pars plicata at a clock

hour advantageous to approaching the existing traction. Core vitrectomy is performed addressing the organized vitreous in 4 planes: transvitreal ridge-to-ridge, ridge-to-periphery, ridge-to-lens, and tentacles from the central stalk of organized vitreous extending from the optic nerve head to the ridge. When this dissection is complete a fluid-air exchange is performed. The sclerotomies are closed and the child positioned so that the air bubble will encourage the retina to be reattached, displacing subretinal fluid.

Lensectomy and vitrectomy

There are cases of advanced ROP for which lensectomy is clearly in order as the lens and retrolenticular vitreous are involved. This is the case for some Stage 4B and most Stage 5 ROP-related retinal detachments. In these eyes either infusing instruments may be used, or an infusion is placed through the limbus inferiorly. A portion of the iris is often sacrificed for visualization and to minimize reproliferation along the posterior iris. Bimanual dissection techniques are employed to free the retina from traction insofar as is possible.

Conclusions

In earlier studies, visual outcome for retinal detachment beyond Stage 4A was quite poor. Advances in understanding the unique anatomy of ROP-related retinal detachments and in vitreous surgery have altered the approach to and prognosis for this condition. Surgical intervention for ROP-related retinal detachment of any stage now offers a realistic opportunity to improve visual prognosis. Maximal recovery of vision following the insult of macula-off retinal detachment and interruption of visual development in infants may take years.

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