CHAPTER 19

Vitreoretinal Surgery and Intravitreal Injections

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Highlights

- Pars plana vitrectomy is typically used for removing vitreous opacities (vitreous hemorrhage), relieving vitreoretinal traction, restoring the normal anatomical relationship of the retina and retinal pigment epithelium, and accessing the subretinal space.
- There are 3 surgical techniques for eyes with primary uncomplicated rhegmatogenous retinal detachment: *pneumatic retinopexy, scleral buckling,* and *primary vitrectomy with or without scleral buckling.* The common goals of these procedures are to identify and treat all causative retinal breaks while providing support through external and internal tamponade as needed.
- Intravitreal injection is the most common procedure in ophthalmology and in medicine in general.

Pars Plana Vitrectomy

Pars plana vitrectomy is usually used for removing vitreous opacities (vitreous hemorrhage), relieving vitreoretinal traction, restoring the normal anatomical relationship of the retina and retinal pigment epithelium (RPE), and accessing the subretinal space. This vitreoretinal surgical technique involves a closed-system approach in which 3 ports are placed 3–4 mm posterior to the surgical limbus, depending on the status of the patient's lens. One port is dedicated to infusion of balanced salt solution into the vitreous cavity to maintain the desired intraocular pressure. Epinephrine can be added to the infusion solution to induce mydriasis and to cause vasoconstriction for reduction of intraoperative bleeding; however, it may promote ischemia and inflammation. Dextrose is often added to infusions to reduce cataractogenesis in phakic diabetic patients. The remaining ports are used to access and visualize the vitreous cavity with tools such as a fiberoptic endoilluminator and instruments to manipulate, dissect, or remove intraocular tissues, fluids, and objects.

Vitrectomy is performed with the use of an operating microscope in conjunction with a contact lens or noncontact viewing system. Direct and indirect visualization are possible; the latter requires the use of an inverting system to orient the image. The advantages of indirect visualization include a wider viewing angle, which enables visualization through media opacities and miotic pupils, as well as when the eye is filled with gas. Although direct viewing systems offer greater magnification and enhanced stereopsis for macular work, their field of view is smaller.

Instrumentation includes a high-speed vitreous cutter, intraocular forceps, endolaser probe, micro-pic forceps, intraocular scissors, extrusion cannula, and fragmatome. Visualization aids include indocyanine green (ICG) or brilliant blue G (BBG) dyes and triamcinolone suspension (Video 19-1). These substances aid in visualization of the internal limiting membrane (ILM) and, in the case of triamcinolone, identification of the vitreous. Perfluorocarbon liquids, which are heavier than water, can be used to temporarily stabilize the retina during dissection and facilitate anterior drainage of subretinal fluid during retinal detachment repair. Tamponade of the retina can be accomplished with use of air, gas, or silicone oil as a vitreous substitute. Commonly used gases include sulfur hexafluoride (SF_6) and perfluoropropane (C_3F_8), which last approximately 2 and 8 weeks, respectively, at nonexpansile, isovolumic concentrations (Table 19-1).

VIDEO 19-1 Triamcinolone-aided pars plana vitrectomy.
Courtesy of Shriji Patel, MD, MBA.

The development of smaller-gauge vitrectomy instrumentation has facilitated transconjunctival, sutureless vitrectomy techniques. With these systems, surgeons place 23-gauge, 25-gauge, or 27-gauge trocar cannulas to align conjunctival and scleral openings and to allow instrument insertions. These cannulas obviate the need for conjunctival peritomy and do not usually require suture closure. The diameter of 20-gauge sclerotomies is 1 mm, compared with 0.7 mm, 0.5 mm, and 0.4 mm for 23-gauge, 25-gauge, and 27-gauge instrumentation, respectively. Potential advantages of small-gauge vitrectomy include fewer

Table 19-1 Properties of Commonly Used Intraocular Tamponades

	Chemical Formula	Expected Expansion	Time to Expansion (hr)	Nonexpansile Concentration	Approximate Duration Inside Eye	Surface Tension (milli-Newton/meter)
Air		–	–	–	5–7 d	70
Sulfur hexafluoride	SF_6	2×	24–48	20%	2 wk	70
Perfluoropropane	C_3F_8	4×	72–96	14%	6–8 wk	70
Silicone oil (1000 cSt)		NA	NA	NA	Until removal in OR	21
Silicone oil (5000 cSt)		NA	NA	NA	Until removal in OR	21

cSt = centistokes (a measure of viscosity); NA = not applicable; OR = operating room.

Information from Schachat AP, Wilkinson CP, Hinton DR, Sadda SR, Wiedemann P, eds. *Ryan's Retina.* Vol 3. 6th ed. Elsevier/Saunders; 2018:2040–2043.

intraoperative iatrogenic retinal tears, shorter operative time, increased postoperative patient comfort, faster visual recovery, and reduced conjunctival scarring.

Chen GH, Tzekov R, Jiang FZ, Mao SH, Tong YH, Li WS. Iatrogenic retinal breaks and postoperative retinal detachments in microincision vitrectomy surgery compared with conventional 20-gauge vitrectomy: a meta-analysis. *Eye (Lond).* 2019;33(5):785–795.

Vitrectomy for Selected Macular Diseases

Macular Epiretinal Membranes

Epiretinal membranes (ERMs; Fig 19-1) have a variable clinical course. See Chapter 15 for discussion of ERM signs, symptoms, and treatment. There are generally 2 indications for surgery: (1) reduced visual acuity or (2) distortion causing dysfunction of binocularity. In general, ERM peel may be advised if visual acuity is reduced (Video 19-2). However, even if the visual acuity is good, vitrectomy may be indicated if difficulty in fusing a normal and a distorted image results in disruption of binocularity.

VIDEO 19-2 Vitrectomy for epiretinal membrane peel.
Courtesy of Colin A. McCannel, MD.

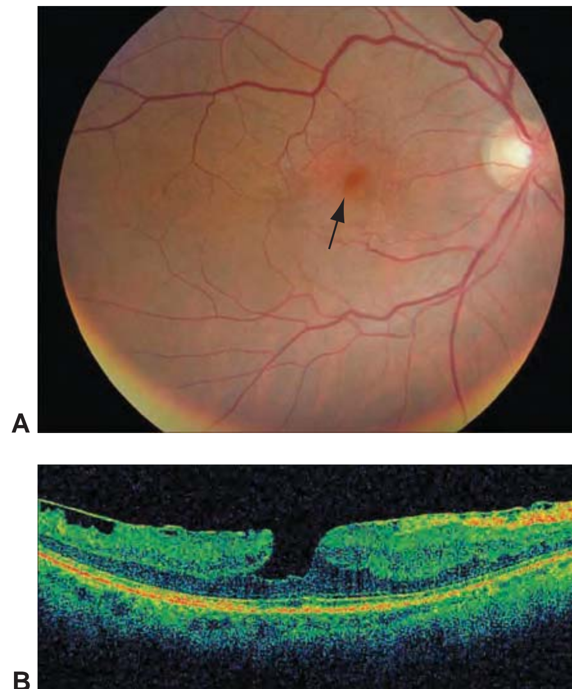

Figure 19-1 Epiretinal membrane. **A,** Fundus photograph shows an epiretinal membrane (ERM) with a pseudohole *(arrow)*. **B,** Optical coherence tomography (OCT) confirms the ERM with pseudohole formation and steepened foveal slope due to contraction of the ERM. *(© 2021 American Academy of Ophthalmology.)*

After surgery, approximately two-thirds of patients achieve an improvement in visual acuity of 2 or more lines. Maximal improvement may take up to 6–12 months (Fig 19-2). Preoperative patient counseling is critical. Although improvement in metamorphopsia is common, complete resolution usually does not occur.

Vitreomacular Traction Diseases

Vitreomacular traction syndrome

Vitreomacular traction (VMT) syndrome is a distinct vitreoretinal interface disorder that is differentiated clinically from typical ERM. VMT syndrome stems from anomalous, incomplete posterior vitreous separation at the macula. The disorder may create focal elevation of the fovea (Fig 19-3) and, occasionally, a shallow retinal detachment. Classically, in eyes with this syndrome, the hyaloid tightly inserts into the macula, usually at or near the fovea, creating traction. Symptoms include metamorphopsia and decreased vision. Surgical treatment consists of a pars plana vitrectomy and peeling of the cortical vitreous from the surface of the retina. Intraoperative use of triamcinolone may aid visualization of the cortical vitreous. See Chapter 15 for further discussion of VMT syndrome.

Idiopathic macular holes

The stages of macular hole formation are discussed in Chapter 15. Vitrectomy is not generally recommended for stage 1 macular holes because approximately 50% of cases without ERMs resolve spontaneously. It is typically indicated for recent full-thickness macular holes (stages 2, 3, and 4). Early intervention for full-thickness macular holes is important; shorter time between the development and the closure of a macular hole has been associated with improved anatomical and functional outcomes.

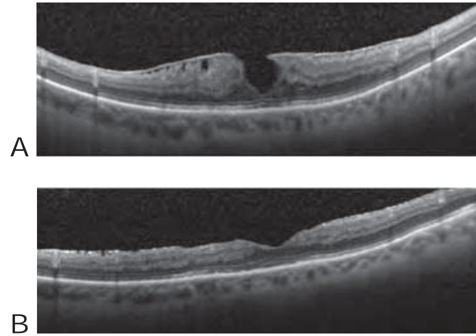

Figure 19-2 OCT images of an ERM forming a pseudohole in a patient with visual distortion and reduced visual acuity (20/50). **A,** A preretinal membrane distorts the retinal contour, and intraretinal edema is present. **B,** Image taken 2 months after surgery shows continued restoration of normal macular contour and absence of the preretinal membrane and traction; visual acuity had improved to 20/25. *(Courtesy of Edward F. Cherney, MD.)*

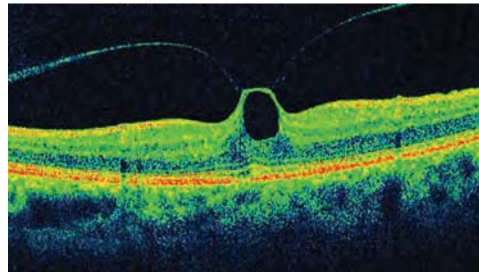

Figure 19-3 Vitreomacular traction syndrome in a patient with visual acuity of 20/60 and mild ophthalmoscopic findings. OCT scan shows a partial posterior detachment with persistent hyaloidal insertion at the center of the macula. Note the elevated fovea with complete loss of contour and inner schisis cavity. Pars plana vitrectomy with membrane peeling led to an improved visual acuity of 20/25 and resolution of symptomatic distortion. *(Courtesy of Stephen J. Kim, MD.)*

Surgery for full-thickness macular holes typically consists of (1) pars plana vitrectomy, (2) separation and removal of the posterior cortical vitreous, (3) removal of the ILM, and (4) use of intraocular air or gas tamponade (Video 19-3). Various studies have demonstrated that ILM peeling improves the rate of hole closure, particularly for larger stage 3 or 4 holes, and reduces reopening rates. *ILM inverted flap* is a newer surgical technique that can be used to close any macular hole (Video 19-4). Intraoperative dyes (eg, ICG, trypan blue, BBG) or other visualization techniques (eg, triamcinolone) are widely used to aid in peeling the ILM. Duration of face-down positioning after surgery ranges from a few hours to 2 or more weeks. Since the early 2000s, most studies have reported macular hole closure at rates higher than 90%, especially for smaller holes (Fig 19-4). After successful closure, it is uncommon for the hole to reopen; however, this may occur if severe cystoid macular edema or ERM develops.

VIDEO 19-3 Vitrectomy with ILM peeling for macular hole repair.
Courtesy of Colin A. McCannel, MD.

VIDEO 19-4 Inverted ILM flap for macular hole closure.
Courtesy of María H. Berrocal, MD.

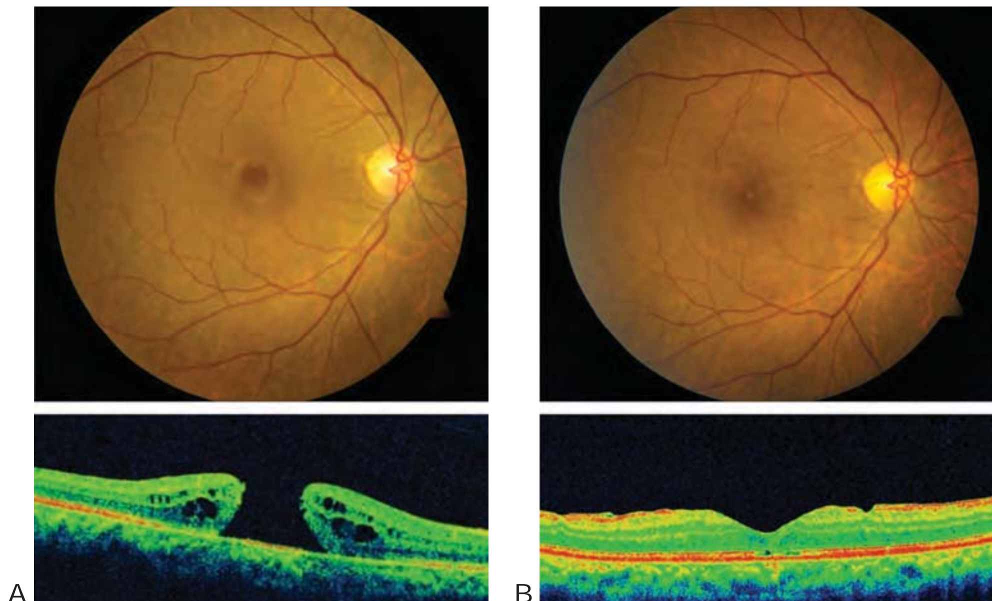

Figure 19-4 Idiopathic macular hole. **A,** Color fundus photograph and corresponding OCT image of a full-thickness macular hole in a patient who had experienced reduced visual acuity (20/100) for 3 months. **B,** Postoperative fundus photograph and OCT image from the same patient. After vitrectomy, membrane peeling, and fluid–gas exchange, the macular hole closed, normal foveal anatomy was restored, and visual acuity improved to 20/25. *(Courtesy of Stephen J. Kim, MD.)*

Kelly NE, Wendel RT. Vitreous surgery for idiopathic macular holes. Results of a pilot study. *Arch Ophthalmol.* 1991;109(5):654–659.

Kumagai K, Furukawa M, Ogino N, Uemura A, Demizu S, Larson E. Vitreous surgery with and without internal limiting membrane peeling for macular hole repair. *Retina.* 2004;24(5):721–727.

Submacular Hemorrhage

Patients with neovascular age-related macular degeneration (AMD) and larger submacular hemorrhages generally have poor visual outcomes. Pars plana vitrectomy techniques may be considered for thick submacular hemorrhage. The surgery involves pneumatic displacement of subretinal blood away from the macular center without attempting to drain the hemorrhage. This technique can be performed with vitrectomy, subretinal injection of tissue plasminogen activator (tPA) via a 39-gauge to 41-gauge cannula, and partial air–fluid exchange (Video 19-5). Postoperative face-down positioning can result in substantial inferior extramacular displacement of the blood (Fig 19-5). Intravitreal injection of expansile gas (eg, SF_6 or C_3F_8) and face-down positioning, with or without adjunctive intravitreal tPA administration, has also been performed in an office setting. Resolution of submacular hemorrhage with improvement of visual acuity can be achieved with administration of

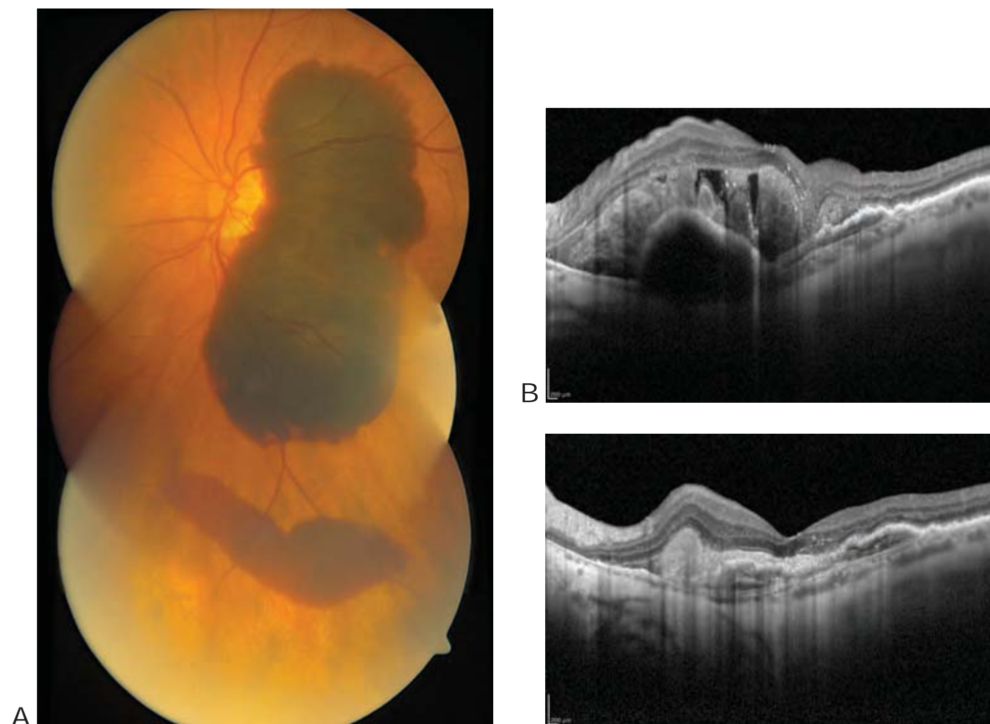

Figure 19-5 Submacular hemorrhage. **A,** Fundus photograph montage shows a large submacular hemorrhage in the setting of neovascular age-related macular degeneration (AMD). **B,** OCT shows large pigment epithelial detachment with overlying subretinal hemorrhage. **C,** OCT taken after pars plana vitrectomy with subretinal tissue plasminogen activator shows resolution of the subretinal hemorrhage with fibrosis. Vision improved from counting fingers to 20/150. *(Courtesy of Shriji Patel, MD, MBA.)*

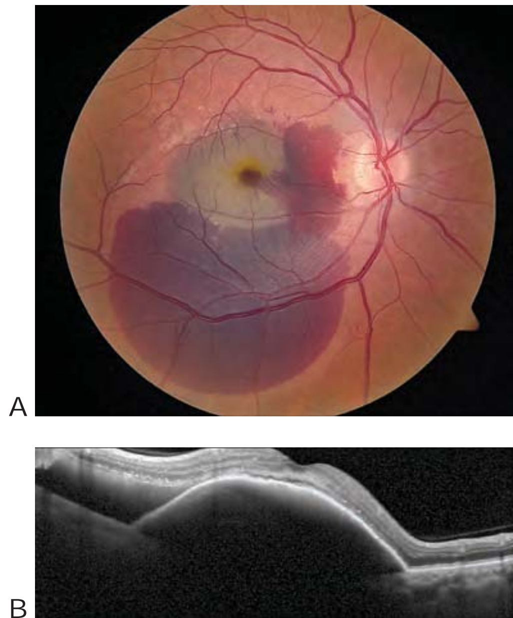

Figure 19-6 Submacular hemorrhage. **A,** Color fundus photograph from a 74-year-old man with 2 days of vision loss and 20/400 visual acuity. Note the lighter-appearing blood in the sub–retinal pigment epithelium (sub-RPE) space in the center and temporal macula versus the darker-appearing blood in the subretinal space in the nasal macula and inferior retina. **B,** Spectral-domain OCT vertical line scan through the macula shows inferior *(left)* subretinal hemorrhage and central sub-RPE hemorrhage. Sub-RPE hemorrhage is not amenable to pneumatic displacement; thus, the patient was treated with intravitreal anti–vascular endothelial growth factor (anti-VEGF) alone, and visual acuity improved to 20/60. *(Courtesy of Kenneth Taubenslag, MD.)*

anti–vascular endothelial growth factor (anti-VEGF) agents alone, which is the only viable option for blood predominantly located in the sub-RPE space (Fig 19-6). Following treatment of the hemorrhage, most patients require anti-VEGF treatment for the exudative AMD.

VIDEO 19-5 Subretinal tPA for macular hemorrhage.
Courtesy of Shriji Patel, MD, MBA.

Vitrectomy for Vitreous Opacities

The majority of patients with vitreous opacities experience improvement without intervention. Nevertheless, surgery to remove vitreous opacities or symptomatic floaters has become more common. Appropriate case selection is necessary, given the 2.6% return to the operating room rate for retinal detachment. YAG vitreolysis can be used as an alternative to surgical removal of floaters, but there is limited high-quality scientific literature assessing the efficacy of this technique, and vision-threatening complications have been reported.

Hahn P, Schneider EW, Tabandeh H, Wong RW, Emerson GG; American Society of Retina Specialists Research and Safety in Therapeutics (ASRS ReST) Committee. Reported complications following laser vitreolysis. *JAMA Ophthalmol.* 2017;135(9):973–976.

Rubino SM, Parke DW III, Lum F. Return to the operating room after vitrectomy for vitreous opacities: Intelligent Research in Sight Registry analysis. *Ophthalmol Retina.* 2021;5(1):4–8.

Vitrectomy for Complications of Diabetic Retinopathy

Advances in vitreoretinal surgical techniques have facilitated earlier surgical intervention in patients with diabetic retinopathy and have resulted in reduced surgical morbidity and

shorter surgical times. In addition, preoperative use of anti-VEGF agents can help reduce intraoperative bleeding; however, it can lead to traction retinal detachment if surgery is significantly delayed after the injection.

Vitreous Hemorrhage

Vitreous hemorrhage is a common complication in patients with diabetic retinopathy. Vitrectomy is indicated when a vitreous hemorrhage fails to clear spontaneously. The timing of the surgery is determined by the surgeon's preference and the patient's visual requirements. Possible indications for more prompt intervention include monocularity, bilateral vitreous hemorrhages, or ultrasonic evidence of a retinal tear or underlying retinal detachment that threatens the macula. In the absence of ophthalmoscopic visualization, serial ultrasonography helps the clinician assess the anatomical condition of the retina.

If surgery is indicated, treatment involves pars plana vitrectomy with removal of vitreous hemorrhage (Video 19-6) and release of the hyaloid from fronds of retinal neovascularization. If present, vitreoretinal traction at the optic nerve head and along the arcade vessels is addressed at the time of surgery, along with any macular ERMs. Complete panretinal photocoagulation and hemostasis should generally be achieved during the procedure. To prevent bleeding or rebleeding, the eye may be filled with air or a short-acting gas to tamponade possible bleeding sites.

VIDEO 19-6 Vitrectomy for vitreous hemorrhage.
Courtesy of Colin A. McCannel, MD.

Diabetic Traction Retinal Detachment

Traction (also called *tractional*) retinal detachment (TRD) occurs when the hyaloid contracts but fronds of neovascular ingrowth prevent it from separating from the retinal interface. The tractional forces are transmitted to full-thickness retina and, in the absence of a retinal break, cause schisis and/or detachment of the underlying retina from the corresponding RPE (Fig 19-7). Vitrectomy is indicated when progression of a TRD threatens or involves the macula. In certain complex cases, spontaneous breaks can also occur in an atrophic retina under traction, resulting in combined traction and rhegmatogenous detachments. Although

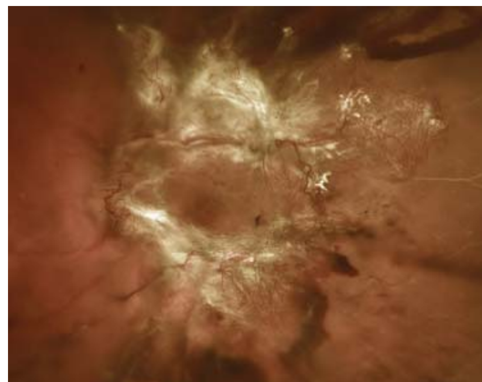

Figure 19-7 Traction retinal detachment in a patient with proliferative diabetic retinopathy. Fibrosis with extensive neovascularization can be seen along the superior and inferior arcades. There is vitreous and preretinal hemorrhage along with sclerotic vessels temporally. *(Courtesy of Shriji Patel, MD, MBA.)*

panretinal photocoagulation should precede vitrectomy whenever possible, it can be more difficult to accomplish in the presence of vitreous hemorrhage. A preoperative adjunctive intravitreal injection of an anti-VEGF agent (3–5 days before surgery) may induce regression of neovascularization, facilitating dissection and minimizing intraoperative bleeding.

During vitrectomy for TRD, the cortical vitreous and posterior hyaloid are removed from the retinal surface (Video 19-7). Point adhesions of cortical vitreous to surface retinal neovascularization can be relieved with use of various instruments, including scissors or the vitreous cutter. Surgical approaches to fibrovascular tissue include segmentation and delamination. In *segmentation,* bands of fibrovascular tissue causing traction are cut, but the epiretinal proliferations are not completely removed. In *delamination,* the epiretinal proliferations are completely, or almost completely, dissected off the retinal surface to relieve the traction. After tractional membranes are removed, diathermy may be used to treat fibrovascular tufts and achieve hemostasis, and supplementary laser treatment may be applied in the periphery to reduce ischemia.

Brunner S, Binder S. Surgery for proliferative diabetic retinopathy. In: Schachat AP, Wilkinson CP, Hinton DR, Sadda SR, Wiedemann P, eds. *Ryan's Retina.* Vol 3. 6th ed. Elsevier/Saunders; 2018.

VIDEO 19-7 Tractional retinal detachment repair with subretinal hemorrhage removal.
Courtesy of Enchun M. Liu, MD.

Diabetic Macular Edema

The current mainstays of treatment for diabetic macular edema are intravitreal anti-VEGF, corticosteroid pharmacotherapy, and photocoagulation (for more information about pharmacologic agents, see Chapter 5). However, vitrectomy with membrane peeling may be considered for recalcitrant cases in which the posterior hyaloid or epiretinal membrane is exerting traction on the macula.

Vitrectomy for Posterior Segment Complications of Anterior Segment Surgery

Postoperative Endophthalmitis

Postoperative endophthalmitis is classified on the basis of time of onset: *acute onset* occurs within 6 weeks after surgery, and *delayed onset* occurs more than 6 weeks after surgery. A specific subtype of endophthalmitis that occurs following filtering bleb surgery has a markedly different spectrum of causative organisms.

Acute-onset postoperative endophthalmitis

Clinical features of acute-onset postoperative endophthalmitis include intraocular inflammation, often with hypopyon, conjunctival vascular hyperemia, and corneal and eyelid edema. Symptoms include pain and vision loss. Common causative organisms are coagulase-negative *Staphylococcus* species, *Staphylococcus aureus, Streptococcus* species,

and gram-negative organisms. Monitoring includes obtaining intraocular cultures. A vitreous specimen can be obtained either by needle tap or with a vitrectomy instrument. A *vitreous needle tap* is typically performed with a 25-gauge, 5/8-inch needle on a 3-mL syringe (to provide greater vacuum) introduced through the pars plana and directed toward the midvitreous cavity. Independent of vitreous sample collection, an anterior chamber specimen may be obtained by using a 30-gauge needle on a tuberculin syringe. Vitreous specimens are more likely to yield a positive culture. Management includes administering intravitreal antibiotics; see Table 19-2 for typical dosing regimens.

Intravitreal antibiotic injections should always be administered after culture samples are collected. Commonly used agents include ceftazidime and vancomycin. Ceftazidime has largely replaced amikacin or gentamicin in clinical practice because of concerns of potential aminoglycoside toxicity. Intravitreal dexamethasone may reduce posttreatment inflammation, but its role in endophthalmitis management remains controversial.

The use of vitrectomy for acute-onset post–cataract surgery endophthalmitis may be guided by the results of the Endophthalmitis Vitrectomy Study (EVS; Clinical Trial 19-1). In the EVS, patients were randomly assigned to undergo either vitrectomy or vitreous tap/biopsy. Both groups received intravitreal and subconjunctival antibiotics (vancomycin and amikacin). The EVS concluded that vitrectomy was indicated in patients with acute-onset postoperative endophthalmitis (within 6 weeks of cataract extraction) with light perception vision (Fig 19-8). Patients with hand motions visual acuity or better had equivalent outcomes in both treatment groups.

Endophthalmitis Vitrectomy Study Group. Results of the Endophthalmitis Vitrectomy Study. A randomized trial of immediate vitrectomy and of intravenous antibiotics for the treatment of postoperative bacterial endophthalmitis. *Arch Ophthalmol.* 1995;113(12):1479–1496.

Chronic endophthalmitis

Chronic (delayed-onset) endophthalmitis has a progressive or indolent course over months or years. Common causative organisms are *Propionibacterium acnes,* coagulase-negative *Staphylococcus* spp, and fungi. Endophthalmitis caused by *P acnes* characteristically induces a peripheral white plaque within the capsular bag and an associated chronic granulomatous inflammation (Fig 19-9A). An injection of antibiotics into the capsular bag or vitreous cavity usually does not eliminate the infection; instead, the preferred treatment is pars plana vitrectomy, partial capsulectomy with selective removal of intracapsular white plaque, and injection of 1 mg intravitreal vancomycin adjacent to or inside the capsular bag (Fig 19-9B). If the condition recurs after vitrectomy, removal of the entire capsular bag, with removal or exchange of the intraocular lens, should be considered.

Table 19-2 Dosing of Commonly Used Intravitreal Antimicrobials

Agent	Dose
Vancomycin	1.0 mg/0.1 mL
Ceftazidime	2.25 mg/0.1 mL
Clindamycin	1 mg/0.1 mL
Amikacin	400 µg/0.1 mL
Voriconazole	100 µg/0.1 mL

CLINICAL TRIAL 19-1

Endophthalmitis Vitrectomy Study

Objective: To evaluate the role of pars plana vitrectomy and intravenous antibiotics in the management of postoperative bacterial endophthalmitis.

Participants: Patients with clinical signs and symptoms of bacterial endophthalmitis in an eye after cataract surgery or intraocular lens implantation; onset of infection occurred within 6 weeks of surgery.

Randomization: Patients were randomly assigned to immediate pars plana vitrectomy or to immediate tap and inject. Patients were randomly assigned to receive systemic antibiotics or no systemic antibiotics and evaluated at regular intervals after treatment.

Outcome measures: Standardized visual acuity testing and media clarity.

Outcomes:

1. No difference in final visual acuity or media clarity whether or not systemic antibiotics (amikacin/ceftazidime) were used.
2. No difference in outcomes between the 3-port pars plana vitrectomy group and the immediate tap/biopsy group for patients with better than light perception visual acuity at the study entry examination.
3. For patients with light perception visual acuity, much better results in the immediate pars plana vitrectomy group:
   a. Three times more likely to achieve ≥20/40 (33% vs 11%)
   b. Almost 2 times more likely to achieve ≥20/100 (56% vs 30%)
   c. Less likely to incur <5/200 (20% vs 47%)

Clinical impact: This study, completed in 1995, revolutionized treatment of post–cataract surgery endophthalmitis by making tap and inject an office procedure for most eyes.

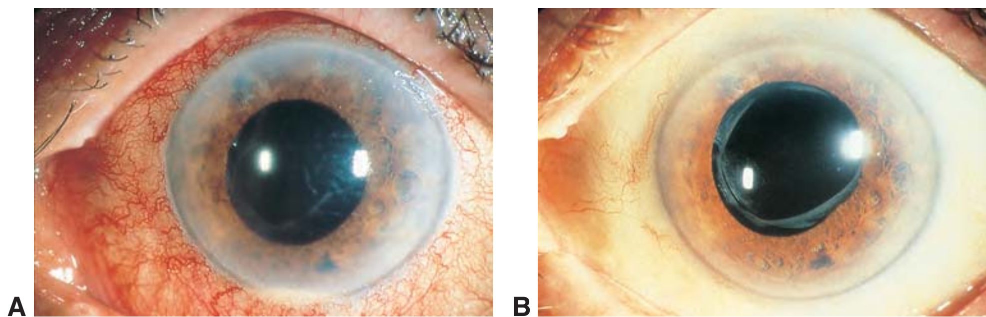

Figure 19-8 Acute-onset endophthalmitis. **A,** Patient with marked epibulbar hyperemia, iritis, and hypopyon indicative of endophthalmitis 5 days after cataract surgery. **B,** After a needle tap of vitreous and injection of intravitreal antibiotics, the inflammation resolved and visual acuity improved to 20/30. *(Courtesy of Harry W. Flynn Jr, MD.)*

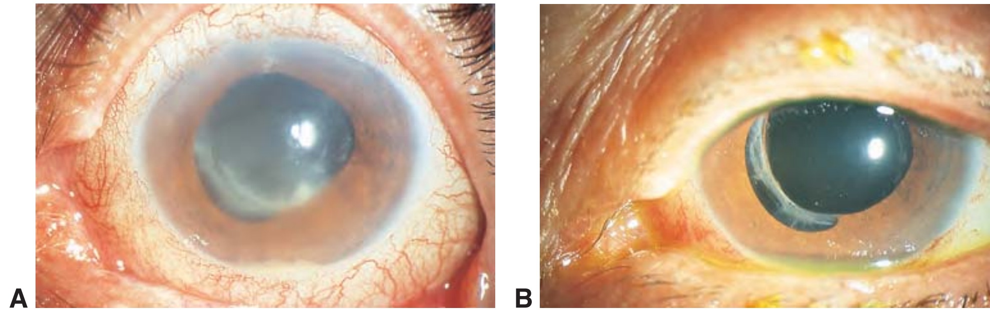

Figure 19-9 Chronic (delayed-onset) postoperative endophthalmitis. **A,** Endophthalmitis in a patient with progressive intraocular inflammation 3 months after cataract surgery. **B,** Same patient after pars plana vitrectomy, capsulectomy, and injection of intravitreal antibiotics. Culture results confirmed a diagnosis of *Propionibacterium acnes* endophthalmitis. *(Courtesy of Harry W. Flynn Jr, MD.)*

Clark WL, Kaiser PK, Flynn HW Jr, Belfort A, Miller D, Meisler DM. Treatment strategies and visual acuity outcomes in chronic postoperative *Propionibacterium acnes* endophthalmitis. *Ophthalmology.* 1999;106(9):1665–1670.

Endophthalmitis associated with glaucoma surgery

Except for the additional sign of a purulent bleb, the clinical features of conjunctival filtering bleb–associated endophthalmitis are similar to those of acute-onset postoperative endophthalmitis. These features include conjunctival vascular hyperemia and noticeable intraocular inflammation, often with hypopyon (occurring months or years after glaucoma filtering surgery; Fig 19-10A). The initial infection may involve the bleb only *(blebitis),* without anterior chamber or vitreous involvement. Blebitis without endophthalmitis can be treated with frequent applications of topical and subconjunctival antibiotics and close follow-up. However, if blebitis progresses to bleb-associated endophthalmitis, patients are treated with intravitreal antibiotics with or without vitrectomy (Fig 19-10B). Likewise, exposed glaucoma drainage implants or microinvasive glaucoma surgery can result in endophthalmitis, typically months to years after surgery.

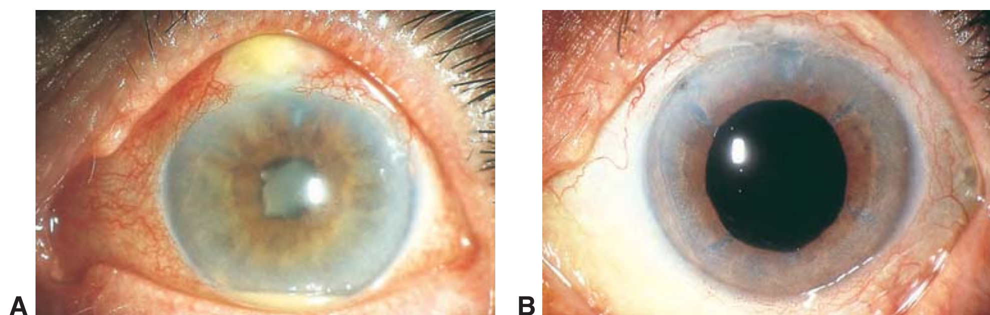

Figure 19-10 Bleb-associated endophthalmitis. **A,** Patient with endophthalmitis who had sudden onset of decreased vision, redness, and pain 2 years after glaucoma filtering surgery. **B,** Same patient after treatment with pars plana vitrectomy and injection of intravitreal antibiotics. *(Courtesy of Harry W. Flynn Jr, MD.)*

Causative organisms frequently include *Streptococcus* spp, *Haemophilus* species, and other gram-positive organisms. The recommended intravitreal antibiotics are similar to those used in acute-onset postoperative endophthalmitis. However, the most common causative organisms in bleb-associated endophthalmitis are more virulent than the most frequently encountered organisms in endophthalmitis that occurs after other intraocular surgeries (such as cataract surgery). Even with prompt treatment, bleb-associated endophthalmitis has visual outcomes that are generally worse than those for acute-onset endophthalmitis after cataract surgery.

Retained Lens Fragments After Phacoemulsification

The incidence of posteriorly displaced, or retained, lens fragments during cataract surgery ranges from 0.3% to 1.1% in reported series. Retained lens fragments may cause severe intraocular inflammation and secondary glaucoma. Nuclear fragments usually continue to cause chronic intraocular inflammation, whereas cortical remnants typically resorb spontaneously (Table 19-3).

Indications for vitrectomy include secondary glaucoma, lens-induced uveitis, and the presence of large nuclear fragments. In the 4 largest reported case series, 52% of patients with retained lens fragments had an intraocular pressure (IOP) of at least 30 mm Hg before vitrectomy. Removal of the lens fragments reduced this incidence by 50% or more in these series. Pars plana vitrectomy, with or without use of a fragmatome, is the preferred approach to remove harder pieces of the lens nucleus (Video 19-8). After the lens fragments are removed, the retinal periphery should be examined for retinal tears or retinal detachment.

Table 19-3 General Recommendations for Management of Retained Lens Fragments

For the anterior segment surgeon
Attempt retrieval of displaced lens fragments only if they are readily accessible.
Perform anterior vitrectomy as necessary to avoid vitreous prolapse into the wound.
Insert an intraocular lens if possible.
Close the cataract wound with interrupted sutures.
Prescribe topical medications as needed.
Refer the patient to a vitreoretinal consultant.
For the vitreoretinal surgeon
Observe eyes with minimal inflammation and/or a small lens fragment.
Continue topical medications as needed.
Schedule vitrectomy
if inflammation or intraocular pressure is not controlled.
if a nuclear fragment or nonresolving cortical fragment is present.
Delay vitrectomy if necessary to allow clearing of corneal edema.
Perform maximal core vitrectomy before phacofragmentation.
Start with low fragmentation power (5%–10%) for more efficient removal of the nucleus.
Prepare for secondary intraocular lens insertion if necessary.
Examine the retinal periphery for retinal tears or retinal detachment.

Modified with permission from Flynn HW Jr, Smiddy WE, Vilar NF. Management of retained lens fragments after cataract surgery. In: Saer JB, ed. *Vitreo-Retinal and Uveitis Update: Proceedings of the New Orleans Academy of Ophthalmology Symposium.* Kugler Publications; 1998:149, 150.

VIDEO 19-8 Vitrectomy for removal of retained lens fragment.
Courtesy of Colin A. McCannel, MD.

Studies with long-term follow-up have reported that retinal detachment occurs in approximately 15% of eyes with retained lens fragments. Aggressive attempts to retrieve posterior lens fragments through a limbal approach are sometimes complicated by retinal detachments caused by giant retinal tears. Giant retinal tears are more commonly found 180° away from the incision used for cataract surgery.

Aaberg TM Jr, Rubsamen PE, Flynn HW Jr, Chang S, Mieler WF, Smiddy WE. Giant retinal tear as a complication of attempted removal of intravitreal lens fragments during cataract surgery. *Am J Ophthalmol.* 1997;124(2):222–226.

Modi YS, Epstein A, Smiddy WE, Murray TG, Feuer W, Flynn HW Jr. Retained lens fragments after cataract surgery: outcomes of same-day versus later pars plana vitrectomy. *Am J Ophthalmol.* 2013;156(3):454–459.e1.

Vanner EA, Stewart MW. Vitrectomy timing for retained lens fragments after surgery for age-related cataracts: a systematic review and meta-analysis. *Am J Ophthalmol.* 2011;152(3):345–357.e3.

Posteriorly Dislocated Intraocular Lenses

Posterior chamber intraocular lenses (PCIOLs) may become dislocated despite seemingly satisfactory capsular support at the time of the initial surgery. Factors to consider when placing a sulcus-fixated IOL include the presence of zonular dehiscence, total amount of anterior capsule support (eg, >180°), size of the eye, and haptic-to-haptic diameter of the IOL. Foldable IOLs have a haptic-to-haptic length of 12.5–13.0 mm. This length, which is frequently smaller than the sulcus-to-sulcus diameter into which the haptics are placed, may contribute to postoperative subluxation or dislocation of the IOL. A flexible IOL may also become dislocated following Nd:YAG laser capsulotomy performed soon after cataract surgery. Late dislocation of the IOL (from several months to decades after surgery) is less common but may occur as a result of trauma or spontaneous loss of zonular support in eyes with pseudoexfoliation syndrome. Treatment options in such cases include observation only, surgical repositioning, IOL exchange, or IOL removal.

In vitrectomy for posteriorly dislocated IOLs, all vitreous adhesions to the IOL are removed in order to minimize vitreous traction on the retina when the lens is manipulated back into the anterior chamber. The IOL may be placed into the ciliary sulcus provided that there is adequate support. If capsular support is inadequate, the IOL may be fixated by suturing the haptics to the iris *(iris fixation)* or sclera *(scleral fixation)* or by placing the haptics into intrascleral tunnels *(intrascleral fixation)*. Alternatively, the PCIOL can be removed through a limbal incision and exchanged for an anterior chamber IOL (Video 19-9) or scleral-sutured IOL (Video 19-10).

VIDEO 19-9 Vitrectomy for retrieval of posteriorly dislocated IOL.
Courtesy of Colin A. McCannel, MD.

VIDEO 19-10 Scleral-sutured IOL.
Courtesy of Shriji Patel, MD, MBA.

Smiddy WE, Flynn HW Jr. Managing retained lens fragments and dislocated posterior chamber IOLs after cataract surgery. *Focal Points: Clinical Modules for Ophthalmologists.* American Academy of Ophthalmology; 1996, module 7.

Cystoid Macular Edema

Cystoid macular edema (CME) that develops after anterior segment surgery usually resolves spontaneously. Treatment with corticosteroid and nonsteroidal anti-inflammatory eyedrops is the first-line approach for patients with persistent CME. Periocular or intravitreal corticosteroids may be used in recalcitrant cases. Oral acetazolamide may also be useful in some cases. Lysis of isolated vitreous wicks in the anterior chamber can be performed with the Nd:YAG laser. Pars plana vitrectomy may be required for more extensive adhesions or anterior chamber vitreous migration. Removal of vitreous adhesions to anterior segment structures may promote resolution of CME and improve visual acuity in select cases (Fig 19-11). An IOL may require repositioning, exchange, or removal if it is thought to be irritating the iris by chafing or capture.

Suprachoroidal Hemorrhage

Suprachoroidal hemorrhage can occur during or after any type of intraocular surgery, particularly glaucoma surgery, in which large variations in IOP are commonplace. By definition, such hemorrhages accumulate in the supraciliary and suprachoroidal space, a potential space between the sclera and uvea that is modified by uveal adhesions and entries of vessels. When retinal surfaces touch one another, the choroidal hemorrhage is termed *appositional,* or *"kissing."* These hemorrhages may be further classified as *expulsive*

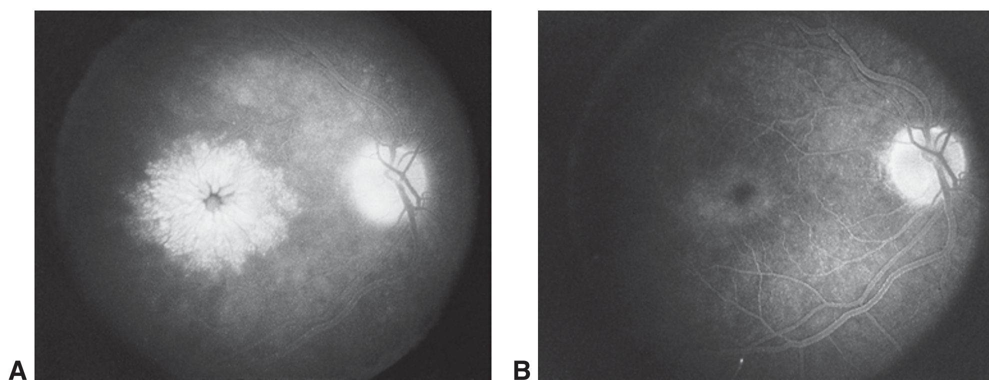

Figure 19-11 Fundus photographs of pseudophakic cystoid macular edema (CME). **A,** Patient has nonresolving CME, vitreous strands adhering to the cataract wound, and a dislocated intraocular lens (IOL). **B,** Same patient after pars plana vitrectomy, removal of vitreous strands, repositioning of IOL, and periocular administration of corticosteroids. CME has improved markedly. *(Courtesy of Harry W. Flynn Jr, MD.)*

or *nonexpulsive;* the expulsive type involves extrusion of intraocular contents. Reported risk factors for suprachoroidal hemorrhage include

- advanced age
- aphakia
- arteriosclerotic cardiovascular disease
- glaucoma
- hypertension
- intraoperative tachycardia
- myopia
- Sturge-Weber–associated choroidal hemangiomas
- use of anticoagulant drugs

Transient hypotony is a common feature of all incisional ocular surgery; in a small percentage of patients, it may be associated with suprachoroidal hemorrhage from rupture of the long or short posterior ciliary arteries.

Surgical management strategies are controversial. Most studies recommend immediate closure of ocular surgical incisions and removal of vitreous incarcerated in the wound, if possible; the primary goal is to prevent or limit expulsion. Successful intraoperative drainage of a suprachoroidal hemorrhage is rare, however, because the blood coagulates rapidly. Most surgeons recommend observation of suprachoroidal hemorrhages for 7–14 days to allow some degree of liquefaction of the hemorrhage. Determining the timing of secondary surgical intervention is aided by B-scan ultrasonography, which enables evaluation of ultrasonographic features of clot liquefaction. Indications for surgical drainage include recalcitrant pain, increased IOP, retinal detachment, and appositional choroidal detachments associated with ciliary body rotation and angle closure. In addition, prolonged IOP elevation in the presence of an anterior chamber hemorrhage *(hyphema)* increases the risk of corneal blood staining and is an indication for surgical intervention.

In surgical management of suprachoroidal hemorrhage, an anterior chamber infusion line is placed to maintain IOP (Fig 19-12, Video 19-11). A full-thickness sclerotomy is

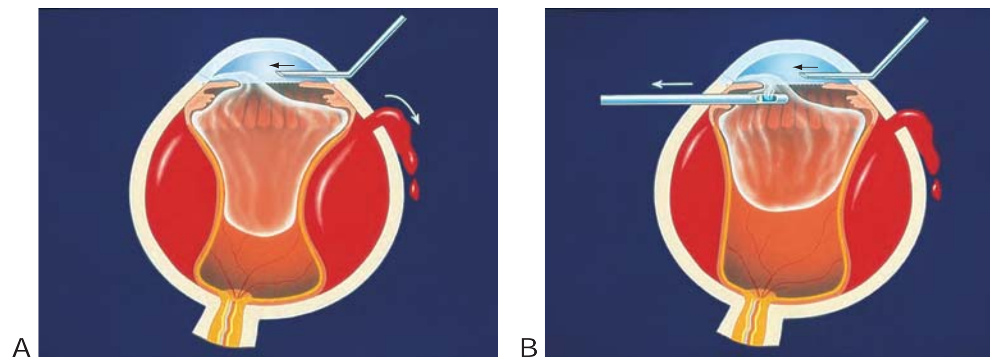

Figure 19-12 Schematic of suprachoroidal hemorrhage drainage. **A,** Anterior infusion and simultaneous drainage of suprachoroidal hemorrhage through pars plana sclerotomy. **B,** Pars plana vitrectomy removes vitreous prolapse while drainage of suprachoroidal hemorrhage continues. *(Courtesy of Harry W. Flynn Jr, MD.)*

then placed subjacent to the site of maximum accumulation of blood. After the suprachoroidal blood drains, pars plana vitrectomy may be performed. Appositional and closed-funnel suprachoroidal hemorrhage, prolonged elevation of IOP, and retinal detachment all portend a poor visual prognosis.

VIDEO 19-11 How to drain a suprachoroidal hemorrhage.
Courtesy of Christina Y. Weng, MD, MBA.

Scott IU, Flynn HW Jr, Schiffman J, Smiddy WE, Murray TG, Ehlies F. Visual acuity outcomes among patients with appositional suprachoroidal hemorrhage. *Ophthalmology*. 1997;104(12):2039–2046. Published correction appears in *Ophthalmology*. 1998;105(3):394.

Needle Injury of the Globe

Factors predisposing patients to needle penetration of the globe during retrobulbar block include

- axial high myopia
- inexperience of the surgeon
- poor patient cooperation at the time of the injection
- posterior staphyloma
- previous scleral buckling surgery
- scleromalacia

Care should be taken to avoid iatrogenic globe penetration at the time of retrobulbar and peribulbar injection of anesthetic or medication (Video 19-12). Resulting injury can occur based on the depth and location of needle penetration, intraocular injection of drug, and globe perforation (Fig 19-13A). Management options vary with the severity of the intraocular damage. Often, blood obscures and surrounds the retinal penetration site, making laser treatment difficult. Observation or transscleral cryotherapy may be considered in such cases. When retinal detachment is present, early vitrectomy with or without scleral buckling is often recommended (Fig 19-13B). Posterior pole damage from needle extension into the macula or optic nerve is associated with a very poor visual prognosis.

VIDEO 19-12 Retrobulbar injection: technique and tips.
Courtesy of Julian D. Perry, MD, Alexander D. Blandford, MD, Joseph D. Boss, MD, and Rishi P. Singh, MD.

Rhegmatogenous Retinal Detachment Surgery

Rhegmatogenous retinal detachment (RRD) occurs when a retinal break (or multiple breaks) allows ingress of fluid from the vitreous cavity into the subretinal space (Fig 19-14). Breaks can be atrophic, often associated with lattice degeneration, or they may be tractional tears related to vitreous traction on the retina and posterior vitreous detachment (PVD). The risk of RRD in otherwise normal eyes is approximately 5 new cases in 100,000 persons per year; lifetime risk is approximately 1 in 300 persons. The most significant risk factors are high myopia,

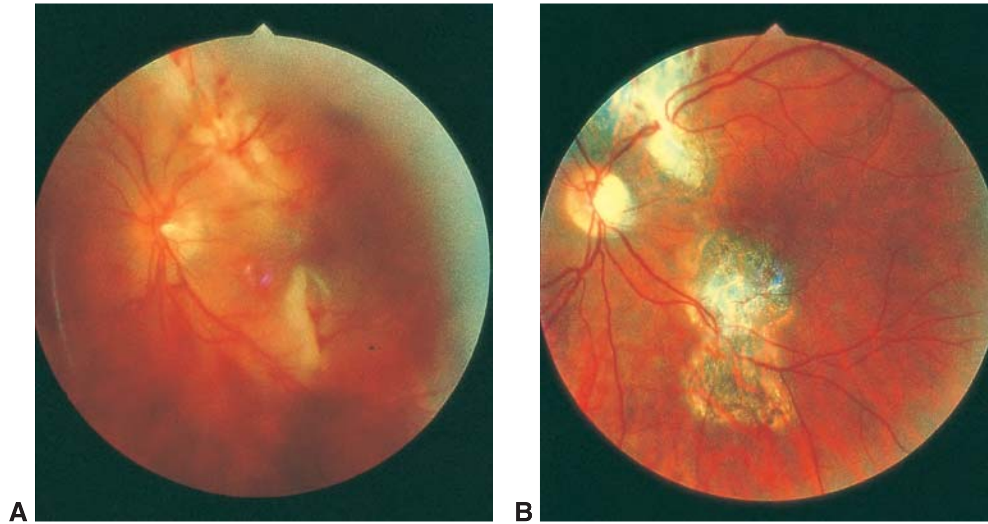

Figure 19-13 Damage caused by needle penetration of the globe. **A,** Multiple retinal breaks and damage to the macula caused by needle penetration of the globe. **B,** After retinal detachment, treatment consisted of vitrectomy, fluid–gas exchange, and endolaser photocoagulation of retinal breaks. Although retinal reattachment was achieved, the patient's visual acuity remained very poor. *(Courtesy of Harry W. Flynn Jr, MD.)*

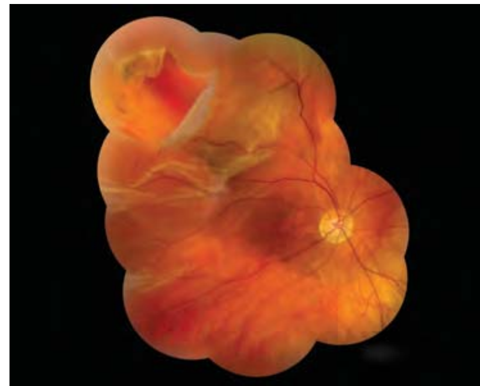

Figure 19-14 Color fundus photograph montage of a patient with symptomatic retinal detachment from a large superotemporal break following cataract surgery. *(Courtesy of Nancy M. Holekamp, MD.)*

family history of retinal detachment, and fellow-eye retinal detachment. Pseudophakia is also an important risk factor; the reported incidence after cataract surgery is less than 1% but increases over time. Patient characteristics that increase the risk of pseudophakic retinal detachment include younger age at the time of cataract extraction, male sex, and longer axial length. A surgical complication such as posterior capsule rupture with vitreous loss has been estimated to increase the risk of retinal detachment as much as 20-fold.

Management options for RRD include laser demarcation of the detachment, pneumatic retinopexy, scleral buckling procedure, and vitrectomy with or without scleral buckling. In rare cases, observation may be considered for select patients with localized retinal detachment surrounded by demarcation line and no associated symptoms (subclinical retinal detachment).

Clark A, Morlet N, Ng JQ, Preen DB, Semmens JB. Risk for retinal detachment after phacoemulsification: a whole-population study of cataract surgery outcomes. *Arch Ophthalmol.* 2012;130(7):882–888.

Powell SK, Olson RJ. Incidence of retinal detachment after cataract surgery and neodymium:YAG laser capsulotomy. *J Cataract Refract Surg.* 1995;21(2):132–135.

Techniques for Surgical Repair of Retinal Detachments

There are 3 surgical techniques for eyes with primary uncomplicated RRD: *pneumatic retinopexy, scleral buckling,* and *primary vitrectomy with or without scleral buckling.* The common goals of these procedures are to identify and treat all causative retinal breaks while supporting such breaks through external and internal tamponade as needed.

Campo RV, Sipperley JO, Sneed SR, et al. Pars plana vitrectomy without scleral buckle for pseudophakic retinal detachments. *Ophthalmology.* 1999;106(9):1811–1816.

Kreissig I, ed. *Primary Retinal Detachment: Options for Repair.* Springer-Verlag; 2005.

Pneumatic retinopexy

Pneumatic retinopexy closes retinal breaks by using an intraocular gas bubble for a sufficient time to allow the subretinal fluid to resorb and a chorioretinal adhesion to form around the causative break(s) (Fig 19-15). The classic indications for pneumatic retinopexy include

- confidence that all retinal breaks have been identified
- retinal breaks that are confined to the superior 8 clock-hours
- a single retinal break or multiple breaks within 1–2 clock-hours
- the absence of proliferative vitreoretinopathy (PVR) grade CP or CA according to the updated Retina Society Classification
- a cooperative patient who can maintain proper positioning
- clear media

With direct pneumatic occlusion of the causative retinal breaks in acute detachments, subretinal fluid is often completely resorbed within 6–8 hours.

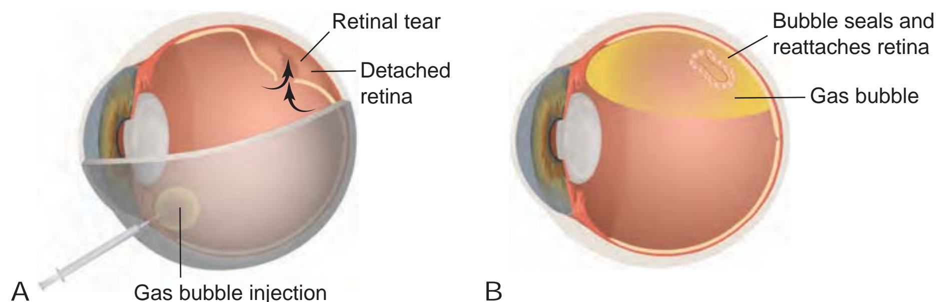

Figure 19-15 Schematic of pneumatic retinopexy. **A,** A small expansile gas bubble is injected into the vitreous cavity. **B,** The bubble enlarges. The patient is positioned so that the gas bubble occludes the retinal break, allowing for retinal reattachment. The break is sealed with either cryotherapy or laser. *(Illustration by Cyndie C. H. Wooley. Part A adapted with permission from Elsevier. From Baino F. Towards an ideal biomaterial for vitreous replacement: historical overview and future trends.* Acta Biomater. *2011;7(3):921–935. doi:10.1016/j.actbio.2010.10.030)*

Transconjunctival cryopexy can be performed on the causative retinal breaks; alternatively, *laser retinopexy* may be performed after retinal apposition. A variety of intraocular gases (eg, air, SF_6, C_3F_8) can be used for tamponade, and a concomitant anterior chamber paracentesis is generally required to normalize the elevated IOP that results from the gas injection. The patient must maintain a predetermined head posture to place the breaks in the least dependent position.

A prospective multicenter randomized clinical trial comparing pneumatic retinopexy with scleral buckling demonstrated successful retinal reattachment in 73% of patients who underwent pneumatic retinopexy and in 82% of those who received scleral buckling procedures; this difference was not statistically significant. Complications from pneumatic retinopexy include subretinal gas migration, anterior chamber gas migration, endophthalmitis, cataract, and recurrent retinal detachment from the formation of new retinal breaks.

Gilca M, Duval R, Goodyear E, Olivier S, Cordahi G. Factors associated with outcomes of pneumatic retinopexy for rhegmatogenous retinal detachments: a retrospective review of 422 cases. *Retina.* 2014;34(4):693–699.

Tornambe PE, Hilton GF. Pneumatic retinopexy. A multicenter randomized controlled clinical trial comparing pneumatic retinopexy with scleral buckling. The Retinal Detachment Study Group. *Ophthalmology.* 1989;96(6):772–784.

Scleral buckling

Scleral buckling closes retinal breaks through external scleral indentation. Transscleral cryopexy is used to create a permanent adhesion between the retina and RPE at the sites of retinal breaks. The buckling material is then carefully positioned to support the causative breaks by scleral imbrication.

The surgeon chooses the scleral buckling technique (eg, encircling, segmental, or radial placement of the sponge, sutured versus scleral tunnels) according to the number and position of retinal breaks, eye size, age of patient, presence of PVD and associated vitreoretinal findings (eg, lattice degeneration, vitreoretinal traction, aphakia), and individual preference and training (Fig 19-16, Video 19-13). Scleral buckling is specifically

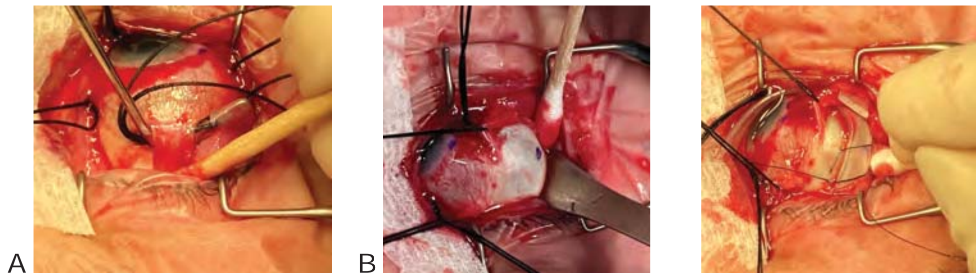

Figure 19-16 Scleral buckling procedure (see also Video 19-13). **A,** The conjunctiva is opened; the rectus muscles are isolated and tagged with a silk suture. **B,** The eye is rotated so the sclera is exposed. Using calipers, the surgeon measures and marks the location for the anterior and posterior scleral pass for the radial mattress suture. **C,** A forceps is used to pass the encircling element under the rectus muscle. Partial-thickness scleral suture passes are made anterior and posterior to the target buckle position. The tied-up radial mattress suture is shown, which will hold the buckle in place. The element can then be tightened to create the desired imbrication. *(Courtesy of Gaurav K. Shah, MD.)*

useful in younger, phakic patients with attached posterior hyaloid, complex detachments involving multiple retinal breaks, and detachments due to retinal dialysis.

VIDEO 19-13 Scleral buckle for rhegmatogenous retinal detachment.
Courtesy of Ravi Pandit, MD, David Xu, MD, and Ajay Kuriyan, MD.

An increase in IOP related to compression from the buckling effect may indicate the need for external drainage of the subretinal fluid, anterior chamber paracentesis, or both. Chronic viscous subretinal fluid, "fish-mouthing" of large retinal breaks, and bullous retinal detachments may necessitate treatment with intraocular gas tamponade, drainage, or both. Complications of scleral buckling include induced myopia, anterior ocular ischemia, diplopia, extraocular muscle disinsertion, ptosis, orbital cellulitis, subretinal hemorrhage from drainage, and retinal incarceration at the drainage site.

Primary vitrectomy

Traction on focal areas of adhesion of the vitreous to the peripheral retina (frequently at the posterior vitreous base insertion) may cause retinal breaks, allowing intraocular fluid to migrate into the subretinal space, which leads to retinal detachment. Consequently, the goals of primary vitrectomy are to remove cortical vitreous adherent to retinal breaks, directly drain the subretinal fluid, tamponade the breaks (using air, gas, or silicone oil), and create chorioretinal adhesions around each retinal break with endolaser photocoagulation or cryopexy.

In general, the 3-port vitrectomy technique is used, employing 20-, 23-, 25-, or 27-gauge instruments. At the surgeon's discretion, vitrectomy can be combined with a scleral buckling procedure. During vitrectomy, a complete posterior vitreous separation is ensured, and the peripheral cortical vitreous is carefully shaved toward the vitreous base to relieve traction on the retinal breaks (Fig 19-17, Video 19-14). The use of intraoperative triamcinolone can confirm complete vitreous separation. To drain the subretinal fluid and achieve intraoperative retinal reattachment, the surgeon can either drain through the causative break, create a drainage retinotomy, or use perfluorocarbon liquid. If PVR is present, it may be necessary to peel the epiretinal (and, less commonly, subretinal) membranes to facilitate the retinal reattachment. For extensive PVR, a relaxing retinotomy or retinectomy may be required.

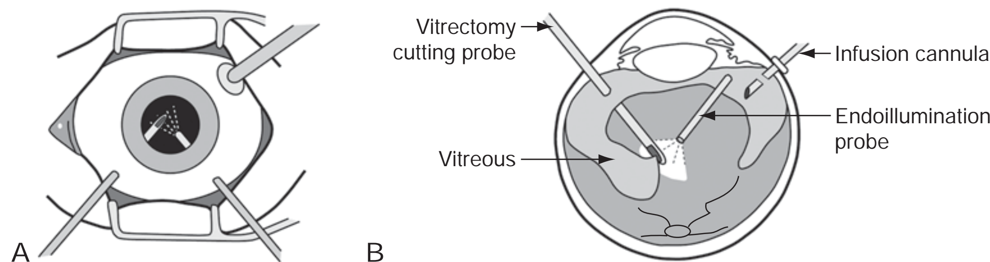

Figure 19-17 Schematic of vitrectomy. **A,** Surgeon's view of a 3-port pars plana vitrectomy. **B,** Cross-sectional view shows an infusion cannula, endoillumination probe, and vitrectomy cutting probe. *(Illustration by Dave Yates.)*

Once the retina is flattened, chorioretinal laser photocoagulation or cryopexy can be applied. Postoperative tamponade is generally provided by intraocular air or nonexpansile concentrations of SF_6 or C_3F_8 gas, although silicone oil may be required in complex cases. Complications of vitrectomy for retinal detachment include postvitrectomy nuclear sclerosis (in phakic eyes), glaucoma, PVR, and recurrent retinal detachment.

VIDEO 19-14 Vitrectomy for rhegmatogenous retinal detachment.
Courtesy of Colin A. McCannel, MD.

Features of *complex retinal detachment* include giant retinal tears, recurrent retinal detachment, vitreous hemorrhage, and PVR. The surgeon may employ pars plana vitrectomy techniques to address the common features of PVR, including proliferative membranes, retinal folds, and media opacities. In the past, controversy surrounded the use of long-acting gas versus silicone oil for retinal tamponade in eyes with complex retinal detachment caused by advanced grades of PVR. This issue was explored in the Silicone Study, a prospective multicenter randomized trial, which concluded that tamponade with SF_6 was inferior to long-term tamponade with either C_3F_8 or silicone oil. Although differences in outcomes between the use of C_3F_8 and silicone oil were statistically insignificant, patients treated with silicone oil experienced a lower rate of hypotony than those treated with C_3F_8.

Vitrectomy with silicone oil or sulfur hexafluoride gas in eyes with severe proliferative vitreoretinopathy: results of a randomized clinical trial. Silicone Study Report 1. *Arch Ophthalmol.* 1992;110(6):770–779.

Vitrectomy with silicone oil or perfluoropropane gas in eyes with severe proliferative vitreoretinopathy: results of a randomized clinical trial. Silicone Study Report 2. *Arch Ophthalmol.* 1992;110(6):780–792.

Outcomes Following Retinal Reattachment Surgery

Anatomical reattachment

In the absence of PVR, the overall rate of anatomical reattachment with current techniques is 80%–90% for the primary surgery. In patients with PVR (an indicator of chronicity) or who have had previous reattachment surgeries, success rates are in the 70% range. However, rates for final reattachment, even if multiple procedures are required, are in the 90%–100% range. Retinal detachments caused by dialyses or small holes or that are associated with demarcation lines have a better prognosis. Aphakic and pseudophakic eyes have a slightly less favorable prognosis. Detachments caused by giant tears or that are associated with PVR, uveitis, choroidal detachments, or posterior breaks secondary to trauma have the worst prognosis for anatomical reattachment.

Sullivan P. Techniques of scleral buckling. In: Schachat AP, Wilkinson CP, Hinton DR, Sadda SR, Wiedemann P, eds. *Ryan's Retina.* Vol 3. 6th ed. Elsevier/Saunders; 2018.

Postoperative visual acuity

The status of the macula—whether it is detached and for how long—is the primary presurgical determinant of postoperative visual acuity. If the macula is not detached

(“macula-on” retinal detachment) and the retinal detachment is successfully repaired, restoration of preoperative visual acuity is usually expected.

If the macula is detached preoperatively *(“macula-off” retinal detachment),* damage to—or degeneration of—photoreceptors may prevent good postoperative visual acuity. Only approximately one-third to one-half of eyes with a detached macula recover visual acuity to the level of 20/50 or better. Among patients with a macular detachment of less than 1 week’s duration, 75% will obtain a final visual acuity of 20/70 or better, as opposed to 50% with a macular detachment of a duration exceeding 7–10 days but less than 8 weeks.

In addition to photoreceptor damage from the detachment, factors associated with visual acuity deterioration or incomplete recovery following successful retinal reattachment surgery include irregular astigmatism, cataract progression, persistent subfoveal fluid, macular edema, or macular pucker.

Complications of Pars Plana Vitrectomy

Nuclear sclerotic cataract is the most common complication of vitrectomy. Within 3–6 months after vitrectomy, as many as 90% of phakic eyes in patients older than 50 years may develop visually significant nuclear sclerotic cataract. Vitrectomy may also increase the long-term risk of open-angle glaucoma. Both cataract progression and glaucoma are speculated to be the result of increased oxygen tension in the eye after vitrectomy, which in turn leads to oxidative damage to the lens and trabecular meshwork, respectively.

Other complications of pars plana vitrectomy include intraoperative retinal tears (approximately 1%–5%), postoperative detachment (approximately 1%–2%), retention of subretinal perfluorocarbon liquid (when used), retinal and vitreous incarceration, endophthalmitis (approximately 0.05%), suprachoroidal hemorrhage, and vitreous hemorrhage (approximately less than 1%; up to 5% and higher in patients with diabetes). Table 19-4 lists some of the complications of pars plana vitrectomy.

Table 19-4 Complications of Pars Plana Vitrectomy

Complications
Complications associated with pars plana vitrectomy
Postoperative nuclear sclerotic cataract
Long-term risk of open-angle glaucoma
Intraoperative or postoperative retinal break
Intraoperative or postoperative retinal detachment
Intraoperative cataract
Postoperative vitreous hemorrhage
Postoperative massive fibrin exudation
Postoperative anterior segment neovascularization
Endophthalmitis
Retinal phototoxicity
Complications associated with silicone oil
Glaucoma
Band keratopathy
Corneal decompensation

Banker AS, Freeman WR, Kim JW, Munguia D, Azen SP; Vitrectomy for Macular Hole Study Group. Vision-threatening complications of surgery for full-thickness macular holes. *Ophthalmology.* 1997;104(9):1442–1453.

Chang S. LXII Edward Jackson lecture: open angle glaucoma after vitrectomy. *Am J Ophthalmol.* 2006;141(6):1033–1043.

Thompson JT. The role of patient age and intraocular gases in cataract progression following vitrectomy for macular holes and epiretinal membranes. *Trans Am Ophthalmol Soc.* 2003;101:485–498.

Intravitreal Injections

Intravitreal injection is the most common procedure in ophthalmology and in medicine in general (Fig 19-18, Video 19-15). The number of injections performed in the United States, estimated from Medicare procedure codes, increased from fewer than 3000 per year in 1999 to an estimated 6.5 million in 2016. The most common indications for these injections include AMD, diabetic retinopathy, and macular edema associated with venous occlusive disease. Intravitreal injections are used most frequently to administer antiangiogenic agents such as aflibercept, bevacizumab, and ranibizumab. Intravitreal injections are also used to deliver steroid preparations and sustained-delivery devices, antimicrobial medications, and various medications currently in clinical trials. The number of intravitreal injections continues to increase as a result of the aging population, the availability of new medications, and an expanding list of indications.

VIDEO 19-15 Intravitreal injection of a pharmacologic agent.
Courtesy of Stephen J. Kim, MD.

Injections can be accomplished safely 3–4 mm posterior to the limbus, depending on the lens status (Table 19-5). Commonly employed methods for administering anesthesia before intravitreal injections include use of pledgets or cotton-tipped applicators soaked with anesthetic and held on the site of injection, application of topical (including viscous) formulations of anesthetic, and subconjunctival injection of lidocaine. There is no

Figure 19-18 Intravitreal injection. The ocular surface was anesthetized with subconjunctival injection of lidocaine, 2%, in the inferotemporal quadrant. An eyelid speculum was inserted, and povidone-iodine, 5%, applied to the ocular surface. After 2 minutes, povidone-iodine was reapplied over the injection site and—after proper hand placement and no talking by the patient or the clinician—the injection was made approximately 4 mm from the limbus. *(Courtesy of Stephen J. Kim, MD.)*

Table 19-5 Steps for Performing Intravitreal Injections

1. Obtain informed consent before performing the injection.
2. Administer appropriate anesthesia (topical or subconjunctival).
3. Insert lid speculum according to provider preference.
4. Apply topical povidone-iodine, 5%, to the ocular surface for a minimum of 90 seconds.
5. Inject the medicine 3–4 mm posterior to the limbus (depending on lens status) with needle tip directed toward the midvitreous.
6. Rinse the ocular surface with sterile saline; topical antibiotics should be avoided as they can promote bacterial resistance.
7. Confirm optic nerve perfusion before patient is discharged from the office. Perform anterior chamber paracentesis if the intraocular pressure remains dangerously elevated.

consensus regarding the optimal method of anesthesia for patient comfort and reduced risk of infection. However, some evidence has suggested that topical lidocaine gel formulations could form a physical barrier that blocks contact between the povidone-iodine used for antisepsis and the ocular surface flora.

Strict aseptic technique, including avoiding contact with the eyelid to prevent contamination of the needle tip from the margin and lashes, is recommended. The application of povidone-iodine, 5%, to the ocular surface for at least 90 seconds prior to injection is widely considered beneficial. Antibiotic eyedrop use before or after injections is not recommended for routine procedures; repeated application of topical antibiotics can lead to development of resistant ocular flora.

Endophthalmitis remains the most-feared complication of intravitreal injection, and the reported incidence ranges from 0.02% to 0.2%. Although respiratory organisms can cause endophthalmitis, the most common source of infection is presumed to be the patient's own conjunctiva or eyelids. Thus, potential mechanisms of infection include direct inoculation of ocular surface bacteria into the vitreous or subsequent entry through a wound track. In addition, multiple studies have reported that *Streptococcus viridans,* a common component of oral flora, is a cause of endophthalmitis after intravitreal injections, presumably from contamination by respiratory droplets. Therefore, restricting talking by both the patient and provider during the procedure and the use of face masks (with the nasal bridge taped to reduce upward airflow) are reasonable practices. In addition, excessive manipulation of the eyelid margin should be avoided to limit expression of bacteria-laden secretions from the meibomian glands, and aggressive treatment of blepharitis should be considered for patients with severe disease.

Outbreaks of endophthalmitis from contaminated bevacizumab have prompted periodic review of compounding pharmacy practices and accreditation status to reduce the risk of future outbreaks. To minimize patient risk when bilateral injections are performed, many practitioners have adopted a workflow in which different lot numbers of compounded medications are used for each eye.

Other complications include the development of elevated IOP following intravitreal injections of anti-VEGF agents or as a common adverse effect of steroid injections. A complication unique to the dexamethasone sustained-release implant is severe corneal endothelial toxicity if the implant migrates into the anterior chamber.

Common patient-reported symptoms after intravitreal injection include ocular surface irritation, subconjunctival hemorrhage, and visualization of injected medication or an air bubble from the syringe. Certain silicone-lubricated syringes can leave microdroplets of intravitreal silicone oil.

Khurana RN, Appa SN, McCannel CA, et al. Dexamethasone implant anterior chamber migration: risk factors, complications, and management strategies. *Ophthalmology.* 2014;121(1):67–71.

Kim SJ, Chomsky AS, Sternberg P Jr. Reducing the risk of endophthalmitis after intravitreous injection. *JAMA Ophthalmol.* 2013;131(5):674–675.

Kim SJ, Toma HS. Antimicrobial resistance and ophthalmic antibiotics: 1-year results of a longitudinal controlled study of patients undergoing intravitreal injections. *Arch Ophthalmol.* 2011;129(9):1180–1188.

McCannel CA. Meta-analysis of endophthalmitis after intravitreal injection of anti-vascular endothelial growth factor agents: causative organisms and possible prevention strategies. *Retina.* 2011;31(4):654–661.

Patel SN, Gangaputra S, Sternberg P Jr, Kim SJ. Prophylaxis measures for postinjection endophthalmitis. *Surv Ophthalmol.* 2020;65(4):408–420.