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Advances in Vitreoretinal Surgery

Baris Komur

Abstract

Vitreoretinal surgery has been radically changed over the past 10 years by the development of new techniques, smaller gauge instrumentation, and improvements in vitrectomy machines. The indications for vitrectomy have expanded dramatically, and inoperable conditions have become amenable to surgical treatment. In addition to improvements in intraocular instruments, various dyes become available and enable better visualization and a more complete removal of vitreous and membranes. In this chapter, we issued latest developments in the surgical field of retina that enable improved surgical outcomes and less complications.

Keywords: vitrectomy, 23 gauge, 25 gauge, 27 gauge, sutureless, retinal detachment, epiretinal membrane, macular hole, silicone oil, c3f8, sf6

1. Introduction

The introduction of pars plana vitreous surgery in the early 1970s, by Dr. Robert Machemer which was a single-port 17 gauge (1.14 mm) system with a cut rate of less than 400 cuts per minute (cpm), is considered as an important step in surgical treatment of vitreoretinal diseases [1]. For the first time, patients with dense vitreous hemorrhage could achieve some visual improvement. Vitreoretinal surgery has changed a lot from that time, firstly by technological improvements in vitrectomy machines. Three-port vitrectomy, better fluidic controls, faster cut rates, better light sources, and smaller gauges are made available to vitreoretinal surgeons [2]. Secondly new techniques and devices like automated fluid-air exchange, endolaser [3], internal tamponades, and dyes make possible to treat different retinal pathologies with less complications. The advent of 23 and 25 gauge vitrectomy made sutureless surgery possible. Improvements in viewing systems and digital image software processing enable good visualization in difficult situations. These advances have enabled vitreoretinal surgeons to more effectively address different serious sight-threatening retinal conditions, including retinal detachments, epiretinal membranes, macular holes, vitreous hemorrhages, phacoemulsification complications, and subluxated intraocular lenses. In this chapter we will discuss latest developments in vitreoretinal surgery that enables improved surgical outcomes and less complications.

2. Improvements in vitrectomy machines

2.1 New probes

The main vitrectomy probe, during the 1990s and 2000s, is made with spring-driven pneumatic cutting mechanism up to 2500 cpm [4]. In these systems,

pneumatic pulses push the cutter to one direction, and the passive recoil of a spring returns the blade to its original position. The limitation of this design is in higher cutting rates; the speed of the spring recoil is not enough to return the blade. For these cutters, when cutting rates approach 2500 cpm, the blade could not fully return to the initial position that the vitrector port is open, so a higher proportion of a cutting cycle is spent with the port closed. Duty cycle of vitrectomy cutter refers to proportion of one cutting cycle in which the vitrectomy port is open. This is important because active removal of vitreous only occurs only when the port is open. Current-generation vitrectomy systems can achieve at least 5000–7500 cpm, but with a traditional spring-driven pneumatic cutter, vitreous removal efficiency may not necessarily proportionally increase with higher cut rates. There are currently two strategies to improve this limitation. A dual-pneumatic-driven cutting mechanism uses separate air lines to control opening and closing of the cutter. In this system, duty cycle is not dependent on the passive recoil of springs and also can be set individually. The other strategy is using a two-dimensional cutter (TDC) approach in which a double-sided blade cuts in both the forward and reverse directions to achieve an effective cut rate of 16,000 cpm with higher duty cycle [5]. The high duty cycle is achieved because the port is nearly always open as the blade moves back and forth. In dual-pneumatic systems, however, duty cycle can be controlled independent of the cut rate. Studies comparing 7500 cpm dual-pneumatic and 16,000 cpm TDC cutters against their traditional counterparts (5000 cpm spring-driven probes) have demonstrated the new technology to significantly decrease the core vitrectomy time with TDC cutters reducing surgery time by 34–50% [6, 7]. Recently, a new mechanism using ultrasound to liquefy vitreous has been developed. The ultrasound harmonic vitrector liquefies the vitreous before being aspirated and has been shown to be safe on cadaveric eyes. These vitrectomy probes have the potential advantage of creating almost no traction during vitrectomy [8, 9].

2.2 Endoillumination and chandelier systems

Endoillumination utilizes an optic fiber inserted into the vitreous cavity through one of the vitrectomy ports. The first generation of endoilluminators utilized halogen, mercury vapor, and metal halide light bulb [10]. However, halogen illuminators required more power as 50% of the luminance was lost [11]. Present vitrectomy platforms utilize xenon or light-emitting diode (LED) light sources. Both have significant luminance through small-gauge light probes and considerably longer bulb life. With increased illumination and spectral distribution, concerns about possible retinal phototoxicity with xenon light sources from wavelengths below 450 nm have been raised. For this reason, most manufacturers have incorporated low-wavelength filters to block the blue and ultraviolet light most toxic to the retina [11]. LED light sources appear to be less phototoxic in animal models at the same intensity [12].

Chandelier lighting system is a stationary, wide-angle endoillumination developed for retinal surgery. It allows the surgeon to use the second hand for bimanual surgical manipulations. Chandelier lighting systems can be placed as single or double fibers and are available in 23, 25, 27, and even 29 gauge sizes. Apart from being used in complicated tractional retinal detachments, chandeliers have been used for primary scleral buckles for better identification of retinal breaks with wide-angle viewing systems [13]. Chandelier-guided scleral buckling is an effective alternative technique to the traditional scleral buckling. Another use of chandelier illumination system is utilizing retroillumination to enhance the poor red reflex that is typical in cases of combined cataract surgery and vitrectomy for vitreous hemorrhage [14]. Details of chandelier lighting system uses in surgery are discussed in "Surgical techniques" of this chapter.

3. Smaller gauges and cannulas

3.1 Smaller incision sizes

In the past two decades, following similar trends of smaller instrumentation in phacoemulsification surgery in the anterior segment, the evolution of vitrectomy surgical techniques that had an exciting advance with vitrectomy scleral incision size has gradually decreased from 20 gauge to 23 gauge and eventually to 25 gauge and 27 gauge through transconjunctival incisions [15].

The smaller gauges have some disadvantages at first. Instrumentation was originally so impractical that many experienced surgeons encounter a learning curve transition from 20 gauge to smaller gauge. Like every new innovation, restrictions in instrumentation and refinement of surgical techniques are needed. Some early difficulties were instruments were too flexible, small-gauge endoil-luminations were weak, and speed of vitreous removal was slow. Improvements in trocar insertion techniques, vitrectomy machine fluidics, stiffer surgical instruments, and valved cannula systems have largely eliminated these issues. Wide range of different stiffer vitreoretinal microsurgical instruments has now been designed for 23 gauge and 25 gauge vitrectomy systems. These include vitreous cutters, trocars, illumination probes, intraocular forceps, micro vitreoretinal blades, tissue manipulators, aspirating picks, aspirators, soft-tip cannulas, curved scissors, extendable curved picks, extendable curved intraocular laser probes, and diathermy probes [16, 17].

Recent introduction of the 25 gauge and 27 gauge vitrectomy systems has some benefits in terms of surgical technique. The cutting port of these probes is closer to the distal end of the tip which gives access to tighter tissue planes during an epiretinal membrane dissection like in diabetic tractional membranes. This manipulation is better than bimanual approach because no instrument change is needed. Combined with the improvements in surgical techniques and better visualization with wide-angle systems, the vitrectomy probe may be used as forceps, scissor, and delamination spatula when necessary without exit from the eye. When a bimanual approach is necessary, chandeliers usually provide an optimal amount of light even the smaller gauges. In these situations, forceps can delaminate any membrane without the need of scissors.

At present, the smallest sclera incision available is 27 gauge. One factor that may lead to a learning curve for 27 gauge is the relative lack of rigidity in the instruments compared to 25 gauge, particularly the intraocular microforceps. Although the main goal of 27 gauge vitrectomy is to create less traumatic wounds, intraoperative surgical times and complications will likely be reduced with this new technology.

3.2 Valved cannulas

Valved cannula systems permit closed system fluidics by limiting exit of fluid which brings various advantages. Maybe the most critical advantage is the exact intraocular pressure (IOP) control that can be kept up consistently during manipulations in trocars, particularly with new IOP stabilization capabilities of current vitrectomy machines.

With reduced flow and turbulence, valved cannulas offer a potential for decreased vitreous incarceration and fewer intraoperative iatrogenic retinal tears, which has been shown in postmortem rabbit eyes [18].

Valved cannulas have few disadvantages also. First it is more difficult to insert soft-tip instruments trough the trocar. Instruments with shorter and more rigid soft extensions and retractable soft tips are useful for insertion. Secondly extra

care must be practiced while injecting extra fluid into system with valved trocars. In particular, injection of perfluorocarbon (PFC) liquid, silicone oil, or gas may require one of the trocars to be open, either by a backflush or another instrument to open the valve, by putting a "chimney" vent or by expelling the valve. A dual-bore injection cannula might be useful to permit departure of liquid trough the other bore during injection. In addition, perfusion at the optic nerve must be persistently observed to prevent excessive IOP rise, during every stage of the surgery.

4. Wide-angle viewing systems

Wide-angle viewing systems (WAVs) are useful fundus observation devices for vitreous surgery, which have been continually developed from the late 1980s based on the indirect ophthalmoscopic principles [19, 20].

Visualization during vitreoretinal surgery is the most important part of the surgery particularly while working on complicated cases. Current WAVs comprise of an indirect ophthalmoscopic lens system for panoramic fundus view. In contact type of WAV, the lens is put on the cornea as a contact lens. In noncontact type of WAV, the lens is placed above the cornea. There is also a prismatic reinverter in the system, which is mounted on microscope or the lens system itself for inverting the fundus view. Contact type of WAVs has a predetermined field angle of view which is dependent on the magnification power of the lens, while noncontact type of WAV angle of view can be adjusted by changing the distance between the lens and cornea. The surgeon can increase magnification of fundus view with two types of WAVs by using zooming function of microscope. The image quality is hypothetically prevalent with the contact type of WAV because of the fact that the aberration and reflection from the cornea can be compensated by putting the contact lens directly on the corneal surface without an interphase [21]. Then again, contact type of WAV frequently needs an accomplished assistant to hold the lens during the surgery.

The WAVs enhance the safety and proficiency of the vitreoretinal surgeries by providing a panoramic view of the retina [21]. Vitreoretinal surgeon can undoubtedly assess the fundus status and the area of retinal pathologies through the panoramic view and evaluating peripheral retina without requiring extreme rotation of the glob as was generally needed when using prismatic lenses [22]. While working in one membrane, visualization of remote traction with possible advancement of retinal tears or hemorrhage is very important in complex surgeries. Complicated surgeries like dissection of anterior proliferative vitreoretinopathy, air-fluid exchanges, and silicone oil injection both an air-silicone oil exchange and direct PFC-silicone oil exchange can be performed with same system without changing settings.

The WAVs developed in recent years additionally encouraged the utilization of microincisional approaches for plana vitrectomy. Utilizing WAVs, the full-degree dissection of the vitreous base, where remaining vitreous frequently causes failure, can be performed with precise control. The modern WAVs improve the vitreoretinal surgeons' manipulative capacities by giving not just a wide-field perspective of the fundus yet additionally provides good-quality video recording of difficult maneuvers. Sharing these videos in meetings or online platforms with other surgeons helps adding to safety and facilitating the technical troubles.

5. Tamponading agents

Tamponade by medical definition is the utilization of a tampon, which itself is characterized as a plug or tent embedded firmly into a wound to arrest hemorrhage.

With regard to vitreoretinal surgery, tamponade agents are utilized to give surface tension over retinal breaks, which counteracts further liquid stream into the subretinal space until the retinopexy (photocoagulation or cryopexy) gives a lasting chorioretinal attachment. Gases and silicone oils are the most commonly used classes of tamponade agents. Silicone oil was initially used without vitrectomy more as an instrument rather than tamponading agent [23].

In addition to the availability of different viscosities of silicone oil (1000 and 5000 centistokes), heavy silicone oil (Densiron) is also available that sinks in water and hence can be used to tamponade inferior retina [24].

PFC liquids are an important contribution made by Stanley Chang to vitreoretinal surgery [25]. These heavier-than-water liquids are used intraoperatively to facilitate various procedures like inverting the flap of giant retinal tear, performing relaxing retinectomies, displacement of subretinal fluid and blood, floating dislocated intraocular lens, and stabilizing posterior pole for peripheral dissection. PFC liquids are mostly used as intraoperative agents and also sometimes used for long term in spite of its toxicity to retina. Silicone oil is still the best long-term tamponading agent available although the search is going on for a better substitute.

Partially fluorinated alkanes combined with silicone oil and two-staged surgeries that involve removing PFC liquid as a second surgery are discussed in "Surgical techniques" section of this chapter.

6. Intraoperative technologies

6.1 Intraoperative optical coherence tomography

In clinical setting, the noncontact method of cross-sectional imaging of the retina with optical coherence tomography (OCT) became an integral part of evaluation, management, and monitoring of wide range of retinal pathologies since the 2000s. [26]. Development of spectral-domain OCT (SD-OCT) provided improvement in resolution and speed of acquisition, which allowed for more detailed visualization [27]. In addition to its role in clinical management, OCT imaging plays an important role in preoperative surgical planning and postoperative evaluation, especially with epiretinal membranes, macular holes, and rhegmatogenous and tractional retinal detachments. Requirement of upright patient positioning and patient cooperation with the conventional tabletop OCT unit precluded its use in supine patients in the operation room. In 2007 a portable and handheld SD-OCT scanner was developed, which allowed imaging of supine patients. It is mainly used for exams under anesthesia for pediatric patients with various conditions, such as retinopathy of prematurity, albinism, and shaken baby syndrome [28–30].

Development of microscope-mounted OCT devices led to a decrease in image capture time and improvement of reproducibility [31–33]. Although this allowed an easier alignment of the system, but real-time visualization of the tissue and tissue-instrument interactions were not possible until the development of microscope-integrated intraoperative OCT (MiOCT) devices [34, 35]. MiOCT systems incorporate the OCT optical path into the common optical pathway of the surgical microscope, allowing improved targeting and tracking of the scan beam and achieving parfocal and coaxial OCT imaging with the surgical view.

The first publication of MiOCT use in vitreoretinal surgery was in 2010, describing a custom prototype system with a research OCT integrated with a commercially available operating microscope [36]. Several prototypes were developed to be used in clinical vitreoretinal surgery, and some have become commercially available [37, 38]. Currently, three systems are approved by the US Food and Drug

Administration for vitreoretinal surgery in clinical setting (viz., Leica EnFocus, Haag-Streit iOCT, Zeiss RESCAN 700).

Better understanding of the vitreoretinal interface disease and intraoperative changes occurred with different surgical techniques, and tissue manipulation can influence surgical decision-making and possibly lead to improved surgical outcomes. Significant advances in software and hardware of MiOCT systems led to examination of their use for different conditions. In vitreomacular traction repair procedures, MiOCT provides real-time assessment of the strength of vitreomacular adhesions and allows visualization of unroofed cysts, subclinical full-thickness macular hole development, and incomplete peeling of membranes. Intraoperative identification of these subclinical changes may alter the immediate surgical approach, such as prompting the use of gas tamponade and potentially preventing the need for reoperation [39]. In retinal detachment surgery, MiOCT aids in detection of residual subretinal fluid, small retinal breaks, and proliferative vitreoretinopathy membranes and can assist in completion of fluid-air exchange. In tractional retinal detachment surgeries, real-time visualization of the planes may also help achieve more precise delamination and segmentation. MiOCT may also offer benefits to regenerative and gene therapies in the future, improving precision of delivery of a therapeutic agent in subretinal space.

Further software and hardware changes will be necessary to address the current MiOCT systems limitations. Known limitations are related to visualization of OCT data on external screens versus surgical oculars, difficulties with imaging peripheral retina, and light scattering and shadowing from surgical instruments. In systems with inocular heads-up display systems, the size of OCT images and the visual field are limited by the size of the surgical oculars. The use of an external monitor for viewing OCT images provides a larger image, but it requires the surgeon to look away from the surgical field. Additionally, MiOCT systems can cause deterioration of image while evaluating peripheral retina, limiting its use in evaluating peripheral regions. Surgical instruments may lead to light scattering and shadowing, limiting to some degree the real-time visualization of retina manipulation. The amount of shadowing varies depending on instrument material, configuration, thickness, and relative orientation to the optical axis of the OCT [40]. Development of instruments that minimize scatter and shadowing may allow for more precise tissue manipulation. The use of semitransparent rigid plastic material instruments may allow decreased light scatter and improved visibility of adjacent tissue as well as the tissue immediately underlying the instruments [41]. Furthermore, development of new software algorithms may assist in software-based processing of the image to minimize shadowing as well as focusing the OCT image to the area of interest.

6.2 Heads-up surgery

Recent developments in three-dimensional (3D) heads-up vitreoretinal surgery viewing are also gaining popularity. New digitally assisted vitreoretinal surgery systems allow surgeons to maintain a heads-up position instead of having to look down through the microscope oculars. 3D high-dynamic-range cameras mounted in place of the microscope oculars, which are connected to a central processing unit, finally project live feed onto screen.

Reported advantages of this system include high magnification; improved ergonomics for the surgeon; a decrease in required endoillumination through enhanced digital signal processing; improved depth of field; ability to overlay diagnostic

studies, including intraoperative OCT data; and enhanced teaching and observation capabilities [42, 43].

Improved ergonomics is the most important advantage of this system. Without the need to lean forward and look into microscope oculars, the surgeon can sit back in the chair and use the backrest for back support. This setup can reduce back and neck strains, especially for long surgeries in complicated cases. Image quality depends on specific conditions, such as distance of the display from the surgeon, angle of the display relative to the surgeon, and minimization of glare. The monitor positioning must be as straight as possible to achieve optimal image quality. Because an assistant sits perpendicular to the patient's head, there is a need for a head turn toward the screen, which may require more time for the assistant to adapt.

With the surgery displayed on the screen, anyone in the room wearing 3D glasses is able to see the details of surgery. This provides an important educational benefit, allowing trainees to observe exactly what the surgeon is doing.

One of the important benefits of digital image processing is being able to use lower endoillumination levels by increasing the camera aperture settings, potentially decreasing phototoxicity, especially for macular cases. Another benefit includes real-time image processing and color manipulation, which can allow better visualization of the vitreous and decreased glare. The increase in depth of field and wider field of view also helps in complex cases, such as proliferative vitreoretinopathy involved in complex retinal detachment, intraocular foreign body, and scleral-fixated intraocular lens cases. Further developments in real-time digital signal processing area also could enhance this technology more.

In summary, new developments in MiOCT systems offer immediate imageguidance for vitreoretinal surgeons; they may improve our understanding of effects of surgical manipulation on tissues and possibly allow us to explain and predict variations in postoperative visual outcomes. Heads-up digitally assisted surgical viewing systems change the ergonomics as well as enhance the viewing and teaching capabilities in the operating rooms.

7. Dyes

For vitreoretinal surgery, vital dyes enable easier identification of the semitransparent preretinal membranes. Current recommendations for the application of dyes during vitreoretinal surgery indicate that indocyanine green, infracyanine green, brilliant blue, and bromophenol blue may be the best stains for the internal limiting membrane (ILM), while trypan blue may be preferred for staining the glial tissues like epiretinal membrane [44].

In regard to the toxicity issues in chromovitrectomy, a large number of experimental and clinical investigations in this challenging field with vital dyes have yielded some controversial results, but preliminary conclusions may be drawn at this time. Indocyanine green has been proven to be toxic to the retina, and brilliant blue showed a better safety profile and could protect against apoptosis, at least in vitro [44, 45].

Each vital dye injected intravitreally poses a rather dose-dependent toxicity to the retinal tissue. Furthermore, there is solid proof that light exposure, osmolarity, and existence of ions, for example, Na + and iodine, may apply further harm to the retina. Along these lines, general proposals for all vital dyes incorporate injection of a very low amount onto the retina, staying away from long macular exposure to endoillumination and expulsion of sodium and iodine from dye solutions.

8. Endoscopic vitrectomy

Endoscopic vitrectomy provides direct visualization of the posterior segment with a directional camera, allowing surgeons to bypass compromised anterior segments, opacified corneas, and media opacities. Additionally, the ability to direct the visualization from the pars plana allows surgeons a method to visualize the anterior retina, ciliary body, and posterior iris surface in their natural anatomic configuration. New techniques are continually being described that demonstrate how endoscopic vitrectomy is beneficial to the retinal surgeon. The most obvious advantage of endoscopic vitrectomy is the ability to provide excellent visualization in eyes with the opacified cornea and lens. It may also allow extreme peripheral panretinal photocoagulation in the patients with peripheral ischemic retinopathies. It allows endoscopic cyclophotocoagulation in patients with glaucoma, either at the time of cataract surgery or as a stand-alone procedure [46].

There are limitations to utilization of an endoscope, such as limited field of view, which requires some adjustment given the familiarity with wide-field viewing systems. Additionally, the view is monocular, so the surgeon must utilize other cues, such as focus, size, and light intensity, to compensate [47]. The free rotation ability of the endoscope probe creates difficulty with orientation, making movements within the eye challenging, especially in the learning period of surgeon. Despite these limitations, endoscopic vitrectomy is a useful addition to the retinal surgeon's armamentarium. The ability to bypass media opacities and to visualize structures otherwise not visible creates opportunities for unique surgical interventions in complicated and even inoperable surgical situations.

9. Surgical techniques

9.1 Scleral buckle

There are variable techniques used for vitreoretinal surgeries, and they are all being continuously refined. Scleral buckle is an example originated in the 1950s but is still developing. Some modifications are still being reported on scleral buckle; as mentioned earlier in this chapter, using chandelier lightning and WAV systems, instead of indirect ophthalmoscopy, becomes the preferred method of choice in many retina clinics. Chandelier assistance obviates the need for indirect ophthalmoscopy and capitalizes on the advantages provided by the operating microscope and modern wide-angle viewing systems such as an improved view of the peripheral retina with oblique lighting to perhaps improve identification of peripheral breaks. Wide-field viewing may also make subretinal fluid needle drainage safer as it may decrease the risk of losing the view of the needle, which may occur with indirect ophthalmoscopy. Moreover, chandelier buckling allows trainers to view same with the surgeon and is better for teaching purposes. In addition, chandelier-assisted scleral buckling permits standard microscope-facilitated recording of the important surgical steps of this procedure, which also facilitates dissemination of scleral buckling techniques. Many authors of the published literature regarding this technique also mention the improved ergonomics of using the operating microscope to perform examination and treatment of retinal breaks instead of indirect ophthalmoscopy [13].

Classic scleral buckle surgery normally incorporates a substantial or 360-degree peritomy. A recent report detailed a method for segmental buckle through a small conjunctival opening, which was utilized in uncomplicated rhegmatogenous retinal detachments [48]. This surgical technique incorporates performing 5 to 6 mm radial

conjunctival cut in close to the retinal break without cutting the limbal conjunctiva and Tenon's layer, followed by cryopexy and implantation of a small segmental buckle that was sutured through the conjunctival opening. Cosmetic and functional results were reported as quick and superb.

9.2 Suprachoroidal buckle

Another imaginative method has been depicted for suprachoroidal buckle surgery. In this method, a lighted catheter is inserted into the suprachoroidal space and placed to any desired area over the breaks; there, an enduring hyaluronic acid filler can be injected to create choroidal indentation. This can be performed with or without pars plana vitrectomy and has been reported effective for the treatment of patients with retinal detachment [49, 50].

9.3 Macular surgeries

Inverted internal limiting membrane (ILM) flap technique has been reported to improve the closure rates of large and persistent macular holes [51]. This technique has recently been suggested for the treatment of macular retinal detachment due to macular holes in highly myopic eyes in which macular holes are relatively difficult to close [52]. Higher rates of macular hole closure and retinal attachment, and additionally a little yet noteworthy improvement in visual acuity, were accomplished with this procedure [53]. It has been recommended that the inverted ILM flap stimulates the multiplication of glial cells that helps in closing the macular hole.

Another interesting new technique has been reported for the treatment of macular folds. Detachment of macula performed by subretinal injection of balanced salt solution and minimal amount of filtered air. Under these conditions, the action of gravity of the PFC liquid and with an active globe rotation has been reported to achieve successful flattening of the macula [54].

9.4 Pars plana vitrectomy for retinal detachment

Development of improved retinopexy methods which could produce immediate chorioretinal adhesion of sufficient strength may obviate the need for long-term tamponade. Recent studies have evaluated the potential of high-frequency electric welding was able to create an immediate retinopexy equal in strength to mature laser retinopexy, which takes about 2 weeks to achieve maximum adhesion [55]. Previously reported methods to achieve adhesion include the development of biocompatible glues, analogous to fibrin [56, 57]. The elimination of long-term gas tamponade and elimination of the need for patient positioning may be the next major advance in retinal detachment surgery.

An interesting technique has been suggested to prevent passage of PFC liquid into the subretinal space. After performing vitrectomy, viscoelastic material was injected over areas where confluent retinal folds were formed with possible retinal breaks. This protective layer still prevents PFC liquid from entering the subretinal space [58].

Pneumatic retinopexy is also an option for retinal detachments caused by within one-clock hour of the retinal arc in the upper two-thirds of the retina and sufficiently clears media to rule out the presence of other retinal breaks. In cases when cryopexy is not performed, it may be difficult to visualize and localize the retinal breaks after the intravitreal gas injection. A recent report of preoperative laser marking of the ora serrata at the meridians of the break made it easy to find after pneumatic retinopexy has been performed [59]. The gas used for pneumatic

retinopexy is usually C3F8 or SF6 at 100% expansile concentration, which allows for injection of a relatively small volume of gas that later expands and can cover a greater area of the retinal surface [60]. The advantage of using air is its faster rate of elimination, which allows the patients to regain good visual acuity sooner (5 days versus 2–4 weeks with the gases).

A recent study reported on proliferative vitreoretinopathy retinal detachment cases, intravitreal conbercept administrated a week prior to surgery. Administration of conbercept, a recombinant fusion protein with antivascular endothelial growth factor (VEGF) activity, was found to reduce the rate of intraoperative bleeding, which can facilitate the management of these difficult cases.

Partially fluorinated alkanes that were introduced as long-term heavy tamponades, which are heavier than water, may be of benefit especially in the treatment of inferior retinal detachment cases. One of these is F6H8, which is not routinely used due to its early dispersion and emulsification with consequent inflammatory response. A study investigated its use in combination with silicone oil, in a series of eyes with inferior retinal detachment, where F6H8 was used to flatten the retina and was later partially mixed with silicone oil for long-term tamponade. This combination resulted in a clear tamponade allowing postoperative visualization of the retina, with no emulsification, inflammation, or other complications [61].

Another option is planning a stage two procedure; after the initial vitrectomy was performed, PFC liquid is infused overlying the optic nerve head until a complete fill of the vitreous cavity was achieved. Patients were instructed to avoid facedown positioning. The staged second procedure was performed 16 to 21 days after all laser scars were noted to be pigmented, with a silicone soft-tip extrusion cannula to remove PFC liquid. Repeated fluid-air/air-fluid exchange was used to remove all PFC from the vitreous cavity. When present anterior chamber PFC also has to be removed [62].

10. Conclusion

The new developments in surgical instruments, machines, trocars, viewing systems, and surgical techniques played significant role in decreasing complications and improving outcomes of modern vitreoretinal surgeries. There are still some problems to solve in modern vitreoretinal surgeries, like finding a better tamponade that does not have necessity to remove from the eye yet also stabilize the retinal breaks better with good visual recovery from the first postoperative day. Also better drugs needed to be discovered to prevent proliferative vitreoretinopathy and hypotony. In addition there are new achievements in stem cell therapies and artificial retinal implants. The progress in vitreoretinal surgery area is ongoing faster than ever before. In the near future, surgery will be an option for a variety of different vitreoretinal pathologies, including cases we classify as inoperable today.

Conflict of interest

The author did not have a conflict of interest for any products mentioned in the above text.

Author details

Baris Komur
Istanbul Haseki Education and Research Hospital, Turkey

*Address all correspondence to: bkomur@gmail.com

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