The saga of vitreoretinal surgery reflects man's ingenuity and how the advances in technology have built upon them an edifice of algorithms which can be used by all ophthalmologists to treat conditions, hence to untreatable, with high success rate. It was in 1920s that Gonin, a Swiss national, suggested that retinal detachments were caused by retinal breaks (tears, holes, dialysis) - and that one could "seal" the break with the surgery. He introduced binocular indirect ophthalmoscope in place of monocular ophthalmoscope which was used till then.

Schepen's binocular indirect ophthalmoscope was a boon for retinal surgeons. He introduced silicone rubber as the buckling material as encircling or a local buckle of various sizes and contours to suit individual patient needs, these continue to be used till today.

Replacement of thermocautery with diathermy by Heim and Weve and later the use of cryoapplication to reduce chorioretinal reaction by Bietti were important advancements during this period.

Schepen's improvisations dramatically revolutionised RD surgery and success rate rose upto 70-80%, which was unthinkable then. But Schepen's approach had one problem, he advocated that buckle be placed intrasclerally after lamellar scleral dissection. This step of lamellar scleral dissection often took a long time but Schepen's method was nevertheless universally adopted and he continued to use it right through the eighties. One of the biggest advantages of Schepen's technique was that retina was attached on the table and need for postoperative bed rest was eliminated.

Next jump in progress of RD surgery was brought in by Custodis a German, in 1953. He used polyvinyl sponge to buckle the break but his breath taking breakthrough was the realisation that drainage of SRF was not essential for reattachment of retina. Custodis non-drainage methods did not have many takers till Harvey Lincoff of Cornell who worked with Custodis popularized the method.

Lincoff preferred silicone sponge to silicone rubber, he replaced cryotherapy for sealing retinal break in place of diathermy and lastly, he stated that retina could be placed externally, thus eliminating the need for lamellar scleral dissection. This was in 1960. Suddenly RD surgery became easier to do. Till today each method has its proponents and opponents. RD surgery success rates were 80-90 percent and commonest cause of failure of RD surgery was proliferative vitreoretinopathy (PVR) and this was untouchable and the eye doomed to blindness.

Around this time microsurgery was finding its place in ophthalmology but vitreous was untouchable. Such was the vitreous sanctity that controversy raged in late 1960s and early 1970s that "can we touch the vitreous and go unpunished". In 1969, the bubble of "inviolability" of vitreous was finally bursted by Kasner, who through cornea, after removing lens, cut and removed opaque vitreous in two patients with primary amyloidosis. These patients regained vision, this was a big step, for it proved that vitreous was expendable.

Another quantum jump was soon made and this was by a colleague of Kasner, Robert Machemer.

Machemer had great insight to realize that best area to approach vitreous for removal was pars plana, for here RPE and anterior continuation of retina is, ciliary epithelium are so firmly adherent that an opening could be made here without causing retinal detachment. To achieve this end he succeeded in devising a motorised instrument with about 18 gauge tip size and working in his garage could remove egg albumin through a small opening in the egg shell. Soon the instrument was used in vitreous related blindness clinically. He called this instrument, vitreous infusion suction culler(VISC). Machemer's technique of Trans Pars plana Vitrectomy (TPPV) included a single 18 gauge port in Pars Plana and introduction of the instrument probe through this opening into the vitreous cavity. This probe would infuse fluid into the eye, cut the vitreous and aspirate it thus removing the vitreous, opaque or otherwise and leave the vitreous cavity filled with BSS or ringer lactate. In many cases of untreatable ocular blindness accompanied by vitreous opacities (haemorrhage etc.) fairly good results were obtained. But his reported first 28 cases of PVR, all failed. Later Machemer added fiber optic light to the probe to be able to see through microscope and corneal lens system right upto the macula clearly by enhancing the illumination.

Connor O'Malley in 1974 proposed three port vitrectomy - all sized 20 gauge.

In lower temporal quadrant was placed infusion cannula to continuously infuse the vitreous cavity with balanced salt solution during surgery and two ports were made close to recti muscles in superotemporal and superonasal quadrants. These two ports being equal sized, opening were interchangeable. Through one port endoilluminator was introduced and through the second port vitrectomy probe
was introduced. This probe would cut the vitreous and aspirate it.

Thus VISC of Machemer which was 18 gauge or of larger size and limited the maneuverability inside the vitreous cavity was replaced by 20 gauge sized instruments which enhanced maneuverability and also permitted use of any instrument which was of 20 gauge size to be introduced into the vitreous cavity. This could be a scissors, foreign body forceps, epiretinal membrane removal instruments like Pics, scratchers. The list is endless. Thus multifunctional VISC was replaced by O'Malley's 3 port vitrectomy systems which continue to be used.

Initial vitreous suction system in 1970s was primitive - assistant hand controlled, surgeons hand controlled, solenoid peristaltic foot control system. In 1976, Steve Charles introduced linear and delta suction controlled system by foot pressure suction pressure could be set to a present level from 0-400 mm Hg. This was a tremendous advance which permitted surgeons to work very close to the retina without fear of causing iatrogenic unintentional retinal tear. Charles also introduced flute needle for internal drainage of SRF. Flute needle now has been replaced by silicone tipped extrusion needle and suction can be controlled from same foot switch which operates the vitrectomy probe.

In eighties, endolasers became available and better bipolar diathermy systems were introduced prolonged intraocular tamponade long acting gas (SF₆) was introduced in 1975 by Norton. Longer acting gas (C,F₃) is in greater use now. Gas gives temporary tamponade varying from 1 to 3 weeks.

For permanent tamponade silicone oils introduced by Cibis et. al. are available in varying range of viscosity from 1000 Cs to 13000Cs. Siliconeoil is lighter than water. Heavier than water silicone oil which flatten the inferior retina is also available, the (flurosilicone). Recently various perfluorcarbon liquids which are heavier than water, have proven valuable intraoperative tools in various vitreo-retinal conditions. These flatten the retina by their heavier specific gravity and have proved extremely valuable in the most feared condition of giant retinal tear.

The last decade has seen a general trend toward efficient, minimal invasive interventions in several areas of medicine. Ever since the introduction of pars plana vitrectomy over 30 years ago, the instrumentarium of posterior segment surgery, too, has been subject to incessant change. In this, two objectives have been in the foreground: one is reducing surgery times, and the other speeding the recovery of the eye. The primary means of reaching these targets lies in instruments that are smaller – and thus induce less surgical trauma – and at the same time more efficient, while affording improved visualization and illumination of the operating field.

On the other hand, the minimization of the instrument diameter and the smaller lumen going with it may have a counterproductive effect on the functionality and efficiency of vitrectomy instruments. For according to Poiseuille's Law the volume flow rate along a pipe is directly proportional to the fourth power of the pipe's radius. When reducing the instrument diameter it is, therefore, to be remembered that the infusion and aspiration rates obtained with this instrument also will be reduced. General improvement or advancement of the instrumentarium has thus relied on balancing the requirements for reduced diameter and the performance of an instrument. The outer diameter of vitrectomy instruments, and others, is given in "gauge" the higher the gauge number, the smaller the outer diameter of an instrument. According to Poiseuille's Law, lower infusion and aspiration rates have to be taken into account when high-gauge instruments (i.e., smaller instrument diameters) are being used and this, in turn, may affect their functionality and efficiency.

Ever smaller instrument diameters have been designed since the early days of "pars plana vitrectomy" in the 1970s, when Machemer, closely followed by Kloti, relocated the access for vitreous removal to the pars plana area to preserve the crystalline lens. While Machemer et al. started out by developing a 17-gauge instrument i.e., the vitreous infusion suction cutter (VISC), that still needed a 2.3-mm sclerotomy port, two decisive advancements were introduced as early as in 1974: for the first time it was now possible to reduce instrument diameters to a marked degree by separating the infusion system and the cutting system. The 20-gauge vitrectomy system (0.9-mm diameter) was born, with infusion, vitrectome and illumination being introduced into the pars plana via three separate ports. Interestingly, splinting to protect the scleral incisions and facilitate instrument change had been propagated already in those days – this concept has been reintroduced, and today is applied to the microtrocar cannulas of the 25-gauge and 23-gauge systems.

While the 20-gauge vitrectomy system was considered the "gold standard" of pars plana vitrectomy, the last 5 years, in particular, have seen fast-paced innovation in the field of the posterior segment instrumentarium toward smaller, more efficient 25-gauge and 23-gauge vitrectomy systems, which nowadays are routinely used in everyday clinical practice.

De Juan and Hickingbotham developed a 25-gauge instrument set for pediatric use already in 1990, since the "conventional" 20-gauge vitreous cutters had proven to be big and lacking in precision, especially in children. This first 25-gauge instrument set, which consisted of just a pneumatic vitrectome, scissors, and a manipulator for membrane removal, at first was used mainly in pediatric surgery, to allow
for higher precision and permit controlled operation even in difficult maneuvers in that particular field.

It was 12 years later, when eventually a complete 25-gauge vitrectomy system was introduced by Fuji et al. which consisted of microtrocar cannulas, affording ease and safety of instrument introduction and withdrawal, as well as an array of integrated 25-gauge instruments. Due to their small diameter (0.5 mm), 25-gauge cannulas allow transconjunctival introduction, thus avoiding the time consuming preparation of the conjunctiva that is required in conventional 20-gauge sclerotomies. Using a trocar with forceps, the conjunctiva, in this procedure, is pulled back a little prior to inserting the cannula, and this displacement provides a slight staggering of the wounds in the sclera and conjunctiva in relation to each other. In 25-gauge vitrectomy, the trocar is introduced perpendicularly to the sclera, i.e., it is directed to the center of the eye. This does not, in fact, create a two-step self-sealing wound. But since the conjunctiva will slip back to its more anterior position, where it is bound to cover the sclerotomy and probably provides a temporary tamponade to the opening – and also in view of the small sclerotomy diameter – no suturing should be required.

As already described, Poiseuille’s Law indicated that the infusion and aspiration rates obtained by the 25-gauge system would be distinctly lower than those of the 20-gauge system. This was confirmed by Fuji et al. in their first evaluation study of the 25-gauge system, where they established markedly reduced infusion and aspiration rates as against the 20-gauge system. To ensure sufficient aspiration rates also for the 25-gauge system, high vacuum settings (500 mmHg) should be used with this system, together with high cutting rates (1,500 cpm), so that optimum tissue fragmentation is guaranteed and “plugging” of the 25-gauge vitrectome is prevented. While the 25-gauge vitrectomy system principally is considered safe and efficient, opinions on the integrity of the sutureless 25-gauge sclerotomies are at variance. Only recently, a modified incision technique was recommended to improve the integrity of sutureless 25-gauge sclerotomies. No significant difference has been identified between 25-gauge vitrectomy and 20-gauge vitrectomy as regards postoperative complications. Sutureless sclerotomies have been at the center of constant concern as regards an increased risk of postoperative endophthalmitis following 25-gauge vitrectomy; however, to date this has never been established. Interestingly, similar apprehensions have been expressed in connection with clear cornea incisions in cataract surgery, but despite some case reports again no increased rate of endophthalmitis could be confirmed.

Due to the limited instrumentarium and high flexibility of the instruments available in the first years, use of the 25-gauge system initially was restricted to “simple vitrectomies” such as removal of epiretinal membranes or macula surgery, procedures which in the opinion of some surgeons did not involve peripheral work or the removal of major vitreous portions. More involved pathologies, demanding extensive removal of the vitreous, initially required the use of 20-gauge vitrectomy systems. Over recent years, widening the array of instruments (e.g., forceps, picks, and other manipulating devices, endolaser), better illumination systems, and specific improvement of the instruments – i.e., by increasing instrument stiffness – has contributed to finally broadening the application range of 25-gauge vitrectomy. The use of silicone oil also was long considered a contraindication of the 25-gauge system, but meanwhile has been made possible by a 25/20-gauge hybrid system for silicone oil infusion. While nowadays silicone oil may be infused through a 25-gauge sclerotome, this process clearly prolongs surgery times. Apart from this expanded range of applications, the increasing experience of surgeons as well as commercial aspects certainly contribute to the fact that 25-gauge technology to some extent is now being used in complicated findings such as proliferative vitreoretinopathy, diabetic retinopathy, and retinal detachment, i.e., in pathologies that require the removal of the peripheral vitreous or the complicated removal of membranes. As before, however, 25-gauge vitrectomy is not suitable for all indications, and in these cases the surgeon must be able to resort to other system.

While the trocar of the first-generation 25-gauge system by Bausch & Lomb was developed on the principle of a hollow needle, which sometimes makes it difficult to introduce, the trocar of the Alcon 25-gauge system is based on a modified V-shaped stiletto blade, so that only a small amount of force is necessary for insertion. The Bausch & Lomb vitrectome is operated electrically, while the Alcon vitrectome is pneumatically driven. Its low weight and resulting ease of handling is considered another advantage of the Alcon system.

There are two decisive benefits invariably mentioned in connection with the 25-gauge system, viz. faster patient rehabilitation and shorter surgery times. As a subjective assessment, most surgeons register more rapid patient rehabilitation or “less postoperative ocular trauma” following the application of a 25-gauge system. It should be remembered that shortened surgery times are primarily due to the fact that opening and closing the eye globe are considerably less time-consuming when a 25-gauge system is used, while vitreous removal is likely to take a little longer, because of the small lumen of the instrument. In spite of its essentially positive aspects, certain limitations to the 25-gauge system persist to date. For instance, the higher flexibility and delicateness that is associated with 25-gauge instruments, as against the considerably more stable 20-gauge (and 23-gauge) instruments, make specific surgeon training a prerequisite.
The accelerated efforts seen over the last 3 years in the development of a 23-gauge system designed to unite the benefits of the 20-gauge and the 25-gauge system were mainly driven by the limitations described for the 25-gauge system. Singh et al. had, in fact, introduced a first electronic 23-gauge vitrectome as early as 1995, which they later complemented by a 23-gauge infusion system. This, however, was not a complete 23-gauge system providing a wide array of instruments, but just a portable system whose use was meant exclusively for vitreous biopsies and minor office-based interventions. Almost 10 years passed before a fully integrated 23-gauge vitrectomy system for routine clinical use had been designed: in 2005 Eckardt in cooperation with DORC (The Netherlands) eventually introduced a complete 23-gauge instrumentarium and demonstrated its safety and efficiency in a first evaluation study.

23-gauge instruments combine considerably higher stiffness and stability than 25-gauge instruments, with a diameter that is smaller than that of 20-gauge instruments; this permits them to be introduced into the eye through transconjunctival sutureless sclerotomies. Unlike the 25-gauge trocars, 23-gauge trocars are not introduced perpendicular to the scleral surface, but at an angle, and instrumentation is brought to a vertical position in subsequent steps. This type of two-step access is designed to facilitate postoperative closure of the sclerotomies by intraocular pressure, ensuring higher integrity of wound closure than with 25-gauge sclerotomies. As early as 2005, Eckardt was able to demonstrate that all 23-gauge sclerotomies were self-sealing and tight. Another very interesting method under anatomical physiological aspects was recently proposed by Rizzo et al., who suggested turning the blade by 30° or a little more. This wound configuration considers the course of the collagen fibers, which ensures even better wound closure. Since 23-gauge instruments can be said to be similar to 20-gauge instruments for stiffness and stability, the training period for a surgeon when switching to 23-gauge is much shorter than with 25-gauge instruments. In addition, distinctly higher infusion and aspiration rates could safely be expected with the 23-gauge system than are obtained with the 25-gauge system, so that careful and extensive vitreous removal – which should continue to be the standard routine – would pose no problem when using the 23-gauge system.

Thanks to higher flow rates plus increased instrument stability, the 23-gauge system may be employed in simple as well as in complicated vitrectomies, and thus is suitable for a wider application range than the 25-gauge systems. The application range of 23-gauge vitrectomy is almost identical to that of the 20-gauge system, while surgery times are shortened and interventions are less invasive; it follows, therefore, that it does combine the benefits of the 25-gauge and 20-gauge systems.

The preliminary results and experience obtained with 23-gauge systems are extremely promising in principle, and 23-gauge vitrectomy may well be able to replace 20-gauge vitrectomy totally in the near future.