Although ophthalmology traces its origins as a surgical specialty to 2000 BC with the first description of cataract couching, retinal surgery is still in its infancy by comparison. Retinal diseases remained a mystery until doctors had a method of actually looking into the living human eye. With Helmholtz’s development of the ophthalmoscope in 1850, retinal surgery as a specialty was born. Being able to fix retinal detachments and cure retinal disease still took time however. Successful retinal surgery was basically non-existent until Jules Gonin introduced his procedure called “Ignipuncture” in 1919. This marks the true birth of retinal surgery. Custodis introduced scleral buckling in 1949, another important milestone. The birth of Vitreous Surgery is largely credited to Robert Machemer in 1972; however it really was the Japanese who really introduced vitreous surgery years before. Tsugio Dodo published his technique of “Open Sky” vitrectomy in 1955, and C. Haruta published his closed vitrectomy technique in 1959.

Birth of Vitreo Retinal surgery

Although the success rates of retinal detachment surgery went to an unthought figure of 80-90%, thanks to the untiring efforts of Gonin, Custodis, Schepens, Harvey Lincoff and many others, proliferative vitreoretinopathy (PVR) remained the most common cause of failure of retinal detachment (RD) surgery. It was deemed to be untouchable and the eye doomed to blindness. 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 burst 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.

Robert Machemer’s Early Vitrectomy with Vitreous Infusion Suction Cutter (VISC) 1972

Robert Machemer, MD (1933-2009) is rightfully regarded as the “Father of Vitreous Surgery” for his introduction of pars plana vitrectomy in 1972. He continued to pioneer not only instrumentation for vitrectomy but our knowledge of the procedure itself. While a faculty member at Bascom Palmer Eye Institute in Miami in the 1970’s, he developed the VISC - one of the first commercially available instruments to remove vitreous. 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 that 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 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 balanced salt solution (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. The 16G instrument was a unimanual, full function probe. Initially, the VISC utilized slit illumination from the microscope, but soon this was replaced by a coaxial illumination sleeve. In addition to the light and aspiration channels, a third channel brought in gravity-fed fluid infusion. This system had a very slow cutting rate at about 1 cut per second. Aspiration was applied manually.

Connor O’Malley in 1974 proposed three port vitrectomy - all sized 20 gauge. Infusion cannula was in the lower temporal quadrant 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. Thus multifunctional VISC was replaced by O’Malley’s 3 port vitrectomy systems which continues 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 sub retinal fluid (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.

### Endolasers and vitreous substitutes

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 (C3F8) is in greater use now. Gases gives temporary tamponade varying from 1 to 4 weeks. For permanent tamponade, silicone oils introduced by Cibis et. al. are available in varying range of viscosity from 1000 Cs to 13000Cs. Silicone oil is lighter than water. Heavier than water silicone oil which flatten the inferior retina is also available (flurosilicone). Perfluorocarbon liquids which are heavier than water have proven valuable intraoperative tools in various vitreo-retinal conditions.

### The First 25G Transconjunctival Vitrectomy Probe

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 instrumentation 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. 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 instrumentation toward smaller, more efficient 25-gauge and 23-gauge vitrectomy.

### Table 1: Milestones of Pars Plana Vitrectomy

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1974</td>
<td>O’Mally and Heintz introduced the 20 guage vitrectomy system</td>
</tr>
<tr>
<td>1974</td>
<td>Eckardt introduces first fully integrated 23 guage vitrectomy system</td>
</tr>
<tr>
<td>1974</td>
<td>Kloti recommends the use of guiding cannulas – the precursors of microcannula – for ease of and added eye protection during instrument change</td>
</tr>
<tr>
<td>1990</td>
<td>Dejuan and Hickingbotham present first 25 guage vitrectomy system whose use however clearly is restricted to specific office based intervention</td>
</tr>
<tr>
<td>1995</td>
<td>At the ARVO meeting, Singh et al, present a 23 guage vitrectomy system whose use however clearly is restricted to specific office based intervention</td>
</tr>
<tr>
<td>2002</td>
<td>Fuji et al present first fully integrated 25 guage vitrectomy system consisting of microcannula cannulas, vitrectome and infusion and demonstrated its safety and efficiency especially in simple vitrectomies</td>
</tr>
<tr>
<td>2004/2005</td>
<td>Eckardt introduces first fully integrated 23 guage vitrectomy system and demonstrates its safety and efficiency</td>
</tr>
<tr>
<td>Upto 2010</td>
<td>Ongoing enhancement of instrumentation and ranges of application of 25 guage and 23 guage system</td>
</tr>
</tbody>
</table>

These flatten the retina by their heavier specific gravity and have proved extremely valuable in the most feared condition of giant retinal tear.
systems, which nowadays are routinely used in everyday clinical practice.

De Juan and Hickingbotham developed a 25-gauge instrument set for pediatric use 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. 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 is required.

The accelerated efforts seen over the last 5 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.

**Improvement in speed**: Not only did the diameter of the vitrector decrease but the cut rate improved significantly which contributed to lesser time taken per procedure. Compared to the cut rate of one/sec in the original VISC system, the modern machines have a cut rate of as high as 5000 cpm and the all new Alcon Constellation® Vision System promises to bring 7500 cpm by the year end.

**The ‘duty cycle control’**: Until now, retinal surgeons could manage flow through a vitrectomy system by controlling 3 surgical parameters: infusion pressure, cutting speed, and aspiration. For the most part, a surgeon could increase flow by decreasing cut rates or increasing aspiration rates. This has changed with the new machines offering substantial improvements in these areas, but also offers control over

### Table 2: Cannula gauge number and corresponding outer diameter

<table>
<thead>
<tr>
<th>Gauge</th>
<th>Outer Diameter (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>17 G</td>
<td>2.3</td>
</tr>
<tr>
<td>19 G</td>
<td>1.1</td>
</tr>
<tr>
<td>20 G</td>
<td>0.9</td>
</tr>
<tr>
<td>23 G</td>
<td>0.6</td>
</tr>
<tr>
<td>25 G</td>
<td>0.5</td>
</tr>
</tbody>
</table>
a very important new parameter; namely, duty cycle. The duty cycle of a vitrectomy probe indicates the percentage of time the port is open measured against the total time of the cut cycle. High flow rates can be achieved with a "biased open" duty cycle, in which the port remains open during most of the cycle, producing greater flow of vitreous into the vitrector. Alternatively, the surgeon can achieve port-based flow limiting with a "biased closed" duty cycle. In this case, the port remains closed for a longer duration, with consequently lower flow.

Improvement in illumination- The development of powerful, safe Xenon light sources as compared to the older halogen systems has come at an opportune time for retinal surgeons to take advantage of 23 & 25G surgical techniques. The newer endoilluminaters are more rigid and provide a wider cone angle of illumination despite smaller light fibers. Chandeliers driven by the Xenon light sources provide a spectacular panoramic viewing environment within which “true” bimanual surgery can be performed safely. Future research hinges on finding ways to maximize illumination levels while at the same time reducing the risk of phototoxicity.

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. With each passing day, the progress is being made and the present generation of retinal surgeons is the witness to these remarkable moments.

---

**Monthly Clinical Meeting, October 2013**

**Venue:** Seminar Hall, 3rd Floor Trauma Block, DDU Hospital, Hari Nagar, New Delhi -110064  
**Date:** 27th October, 2013 (Sunday)

- **Tea with Snacks & Registration:** 10:00 a.m. Onwards
- **50 Early Bird Prizes**

**Clinical Session:** 11:00 a.m. onwards

**Clinical Cases:**
1. **mins Choroidal Granuloma-Atypical presentation of Ocular Tuberculosis**  
   *Discussant:* Dr. Rima Jain  
   10 mins

2. **Desferrioxamine induced bilateral CSR-in a case of Thalassaemia**  
   *Discussant:* Dr. Amit Mehtami  
   10 mins

**Clinical Talk:**
- **Update on Management of Diabetic Retinopathy**  
  *Chairman:* Dr. M.C. Agarwal  
  15 mins

**Mini Symposium:** Technological Innovations in Newer IOLS - Controversies & Limitations

- **Chairman:** Dr. S. Bharti, **Co-Chairman:** Dr. J.S. Titiyal, **Convenor:** Dr. M.C. Agarwal

1. **Aspheric IOLs- Facts & Myths**  
   *Chairman:* Dr. J.S. Bhalla  
   12 Mins

2. **Accomodative IOLs - Has their time come**  
   *Chairman:* Dr. H.C. Gandhi  
   12 Mins

3. **Toric IOLs -Conceptual analysis of residual astigmatism after Toric IOL Implantation**  
   *Chairman:* Dr. N.Z. Farooqui  
   12 Mins

4. **ICL**  
   *Chairman:* Dr. Rajesh Hans  
   12 Mins

**Lunch**

**Programme Sponsored by - M/s. Shelon Pharmalab**