

# Macular hole : Surgical Update

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Macular holes are full thickness defects in the neurosensory retina from the internal limiting membrane to the photoreceptors. Partial thickness macular holes or the lamellar holes do not involve all the layers of retina. Our understanding of the etiopathogenesis of macular holes have certainly been enhanced by the recent developments in the OCT and better visualization of the vitreoretinal interface.

## HISTORY:

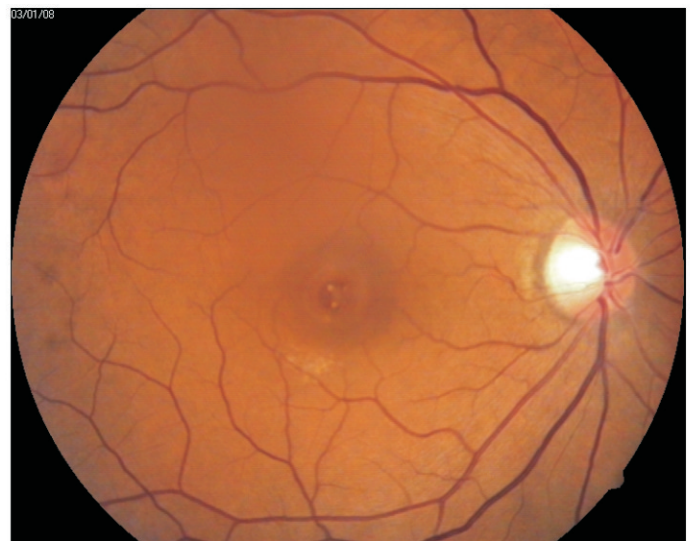
Knapp<sup>1</sup> and Noyes<sup>2</sup> were the first to describe the macular hole in 18 century. The cause of macular holes can be idiopathic, myopic, associated with cystoid macular edema, retinal vascular diseases, retinal detachment. Macular holes are also known to occur with lightning strike<sup>3</sup> and with hypertensive retinopathy<sup>4</sup>. Most of the macular holes occur as age related idiopathic condition not related to specific preceding events or ocular problems<sup>5,6</sup>. It has been observed that macular holes are common in females with reported incidence being 67% to 91%. Various causative factors and various theories have been propagated to explain the mode of development of macular holes. These theories look into mechanical, vascular, inflammatory causes of macular holes. The idiopathic macular holes have been staged by Gass and he had put forth the theory of tangential traction by the attached posterior vitreous on the fovea lead to macular hole in majority of cases.

## ETIOPATHOGENESIS

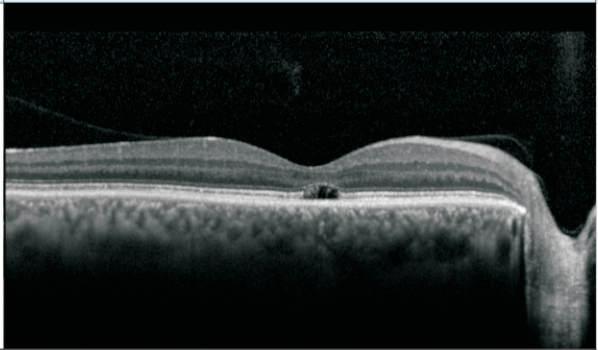

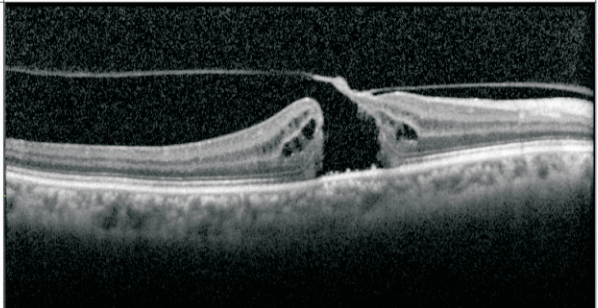
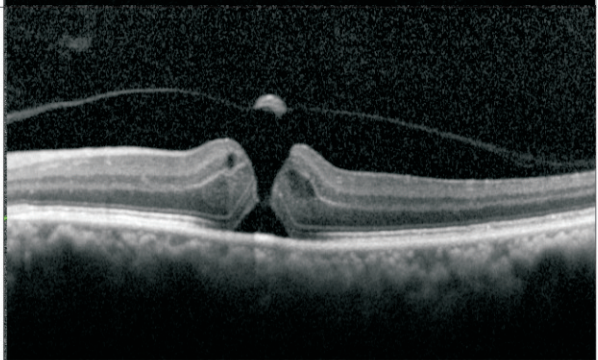

It has been observed that among the macular holes of stage 1A/B,

60% eyes undergo a spontaneous vitreofoveal separation and there is no further progression<sup>7,8,9,10</sup>. The remaining 40% progress to stage 2/3<sup>11,12</sup>. Advent of OCT has helped us in understanding the intricacies of the vitreoretinal interface, it has been observed that perifoveal vitreous separation is the antecedent event in macular hole formation<sup>12,13,14</sup>.

The currently accepted concept for the development of macular



**A1 Pre op Clinical picture of a macular hole**

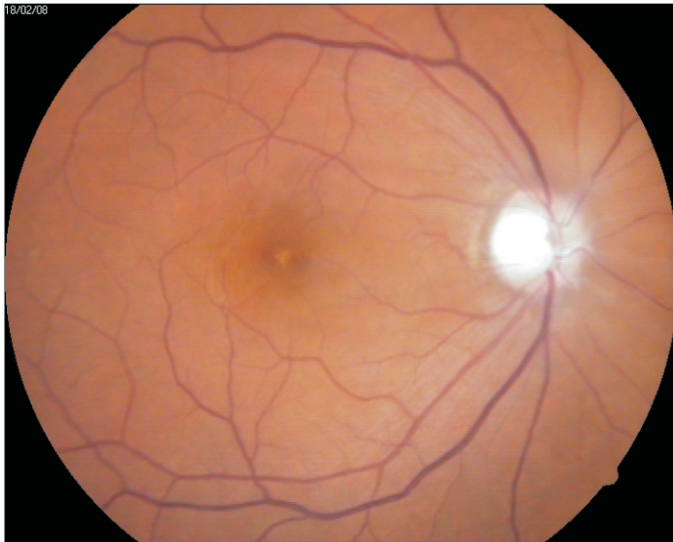
Sr no	Stage of macular hole	Special features	OCT
1	Stage 1a	yellow spot 100-200 $\mu\text{m}$ in diameter, resulting from a foveolar detachment secondary to spontaneous tangential traction by the prefoveolar vitreous cortex	
	Stage 1b	yellow ring of approximately 200-300 $\mu\text{m}$ in size centered on the foveola	
2	Stage 2	a full-thickness macular hole (<400 $\mu\text{m}$ ), pseudoepithelium	
3	Stage 3	holes larger than 400 $\mu\text{m}$ associated with partial vitreomacular separation	
4	Stage 4	complete separation of the vitreous from the entire macula and optic disc	

## SURGICAL CARE

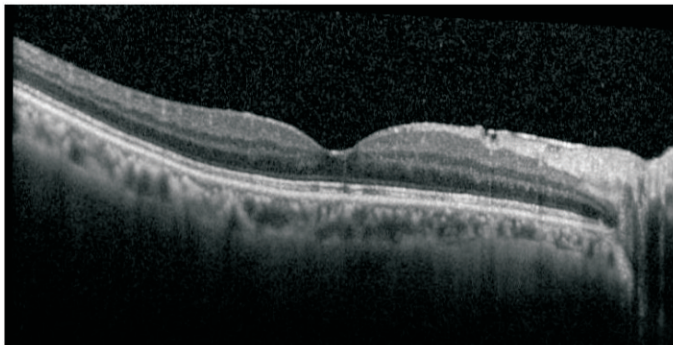
### Macular Hole Surgery

Macular hole surgery has undergone a paradigm shift from the days of considering the pathology as untreatable to the modern day vitrectomy where better understanding of the disease process and advances in the instrumentation have enabled to give

promising results. In the early days surgery was indicated only if the macular hole was associated with retinal detachment<sup>15,16,17,18</sup>. The following days saw a growing interest in the prophylactic measures for macular hole. Vitrectomy was also considered as a prophylactic measure<sup>8,19,20</sup>. However in a subsequent larger multicentric trial the surgical benefit of vitrectomy in prevention of macular holes was not observed<sup>9</sup>. Laser photocoagulation at



**A2 Post op Clinical picture of the closed hole with its corresponding OCT**



**A3 Post op Clinical picture of the closed hole with its corresponding OCT**

the rim of macular holes was used to facilitate the closure of the macular hole however the destruction of the neurosensory retina and RPE due to photocoagulation has limited its widespread use<sup>21,22</sup>.

Kelly and Wendell in 1991 were the next to suggest that the macular hole closure can be achieved by relieving the tangential traction over the macula by removing the vitreous cortex through vitrectomy stripping the epiretinal membrane, total air fluid exchange and tamponade by the nonexpansile concentration of sulfur hexafluoride. This finding brought about a paradigm shift in the management of macular holes. Since then vitrectomy has been accepted treatment of macular hole (figure A1, A2, A3).

#### Which Holes to treat?

Surgery can be done for any stage of macular hole. However the most important factor to be considered is the visual handicap of the patient in relation to the macular hole. The level of improvement is determined by rule of thumb in which eyes with better preoperative visual acuity are associated with better postoperative visual acuity. Long standing grade 4 holes don't do very well inspite of surgery and could be left alone if the visual loss is not recent. However a grade 1 hole in the other eye of a patient who already has a macular hole in one eye would do very



**B1 Injection of triamcinolone into vitreous to stain the posterior hyaloid**

well with surgery. If the vision in the eye with macular hole is less than 20/200 then additional factors (neurological, ischemia, degeneration, glaucoma, traumatic maculopathy) playing a role in visual loss should be suspected. Therefore the macular holes associated with diabetic TRD are often left alone.

Pharmacological closure of the Macular hole: It has been proposed that ocriplasmin can achieve pharmacological closure of the macular holes when injected intravitreally in addition to resolving the symptomatic vitreomacular adhesion.<sup>23</sup>

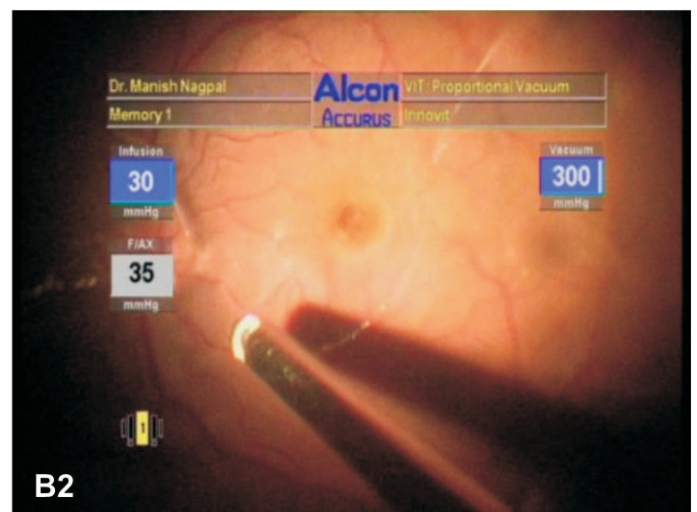
#### Surgical technique

##### 1) Pars Plana Vitrectomy:

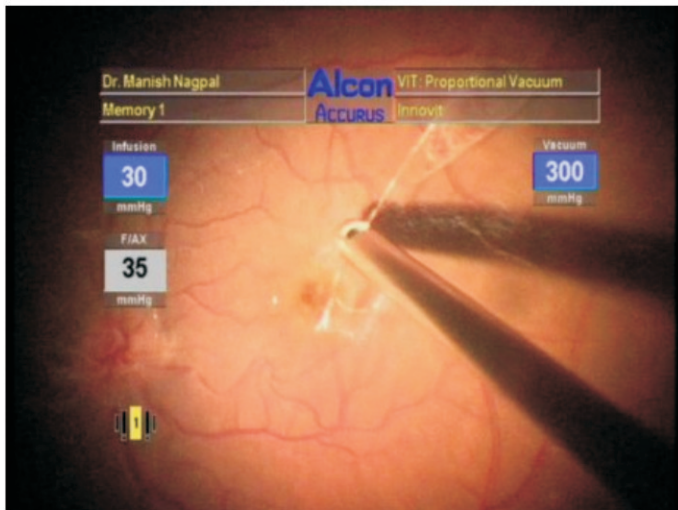
A standard three port pars plana vitrectomy is performed. Small gauge surgery using 25 g or 23 g instrumentation is increasingly getting popular for this procedure.

##### 2) Injecting Intravitreal Triamcinolone to stain hyaloid :

Intravitreal staining of the posterior hyaloid is a useful step (figure B1). It helps delineate the hyaloid attachment to the macular as well as disc area. It makes the procedure safer since



**B2**



**B2 and B3** After clearing residual triamcinolone the cutter port is used vacuum mode to pull the halo of the stained posterior hyaloid

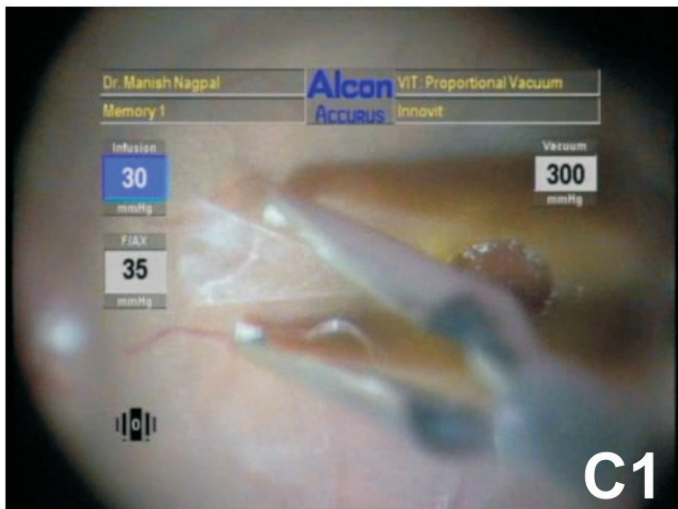
the surgeon can easily distinguish these borders and use the suction for the PVD creation quite efficiently. Also the residual crystals remaining over the retinal surface after hyaloid creation help the surgeon with the ILM peeling as well.

### 3) Posterior vitreous detachment:

Posterior vitreous detachment can be achieved by various ways

- 1) Active suction created with the cutter port in the vacuum only mode or by using a silicon tip cannula
- 2) Sharp dissection of membrane pick or barbed MVR blade creating an opening in the posterior hyaloid.

We prefer the first one with active suction exerted with the cutter mouth itself. Continuous high vacuum is exerted with cutter



**C1, C2 and C3** Steps in peeling the Internal limiting membrane with a forceps. Note the fine particles of triamcinolone which also help identifying the margins of the ILM

mouth facing the hyaloid borders around the disc which are stained conveniently with triamcinolone. With the cutter is engages the hyaloid, the suction is raised and slowly the whole

hyaloidal complex can be usually seen peeling away from the retinal surface (figure B2 and B3). If one uses a silicon tip cannula instead, the tip of the cannula bends and this has been described as the classic “fish strike sign”.

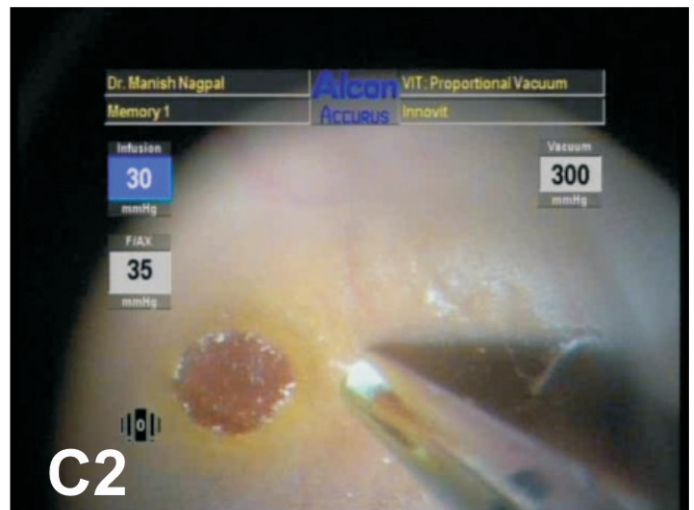
### 4) Further Residual vitrectomy:

Once the hyaloidal separation is made effectively the residual vitreous is cleared with the cutter right upto the equator and beyond. The extreme periphery need not be approached for all cases.

### 5) ILM/ Pucker removal:

#### ILM peeling:

Clinically the epiretinal membranes are seen in 15% of macular holes, however histopathologically this statistic rises to 75% of the macular holes. The membranes can be removed with a standard end gripping forceps with a good platform. After that the



ILM is peeled. The ILM peeling is started by making a scratch on the ILM with a barbed MVR blade<sup>23</sup>, scraper or extrafine ILM forceps. Once the edge of the ILM is found then it is peeled off by performing maculorrhexis (Figure C1, C2, C3). We routinely do the ILM peeling in cases of stage 3 or stage 4 macular holes. Various techniques and stains have been used by surgeons to



facilitate this procedure. The ILM peeling to facilitate the hole closure has put forth the challenge of visualization of the ILM. We do not use any stain other than the residual crystals of triamcinolone which help delineate the flap margin once it is made. The most popular stain is the Indocyanine green and the other recently popular and probably with less concerns of toxicity is the Brilliant blue stain. Some surgeons like to mix the stain with a viscoelastic and only selectively stain the macular

area and some put a drop of Perfluorocarbon over the bare hole to protect it prior to using the stain. Whether one uses a stain or not the best recommendation is to finish the peeling procedure as fast as possible so as to reduce the chance of photo toxic damage. It is important that the exposure of the light pipe to the macula is kept to minimum to avoid the phototoxicity.

#### Techniques to identify ILM:

SR No	Stains /Adjuncts	Target of the stains	Method of use
1	Triamcinolone acetate	Posterior hyaloid	Used on 26 gauge needle during PVD induction
2	Methylene blue	ILM	Used under air to prevent staining of posterior lens capsule
3	ICG	ILM	Used under air to prevent staining of posterior lens capsule
4	BBG	ILM	Can be used with fluid
5	Autologous heparinized blood	ILM	Cost effective method to stain ILM. It is used under air. <sup>29</sup>

**Method of peeling:** The ILM should be peeled with number of grasping movements, each grasp at the base of the ILM flap so as to exert a tangential force to achieve a good circular rhexis like motion about one disc diameter around the macula. Sometimes there is appearance of bleed from the nerve fibre layer capillaries which is in fact the indication of the correct plane of the peel. While starting the peel some surgeons prefer using a Tano Diamond Dusted Scraper to start the creation of the flap. We use a 25/23 gauge greishaber ILM peeling forceps to directly pinch the ILM and then tangentially remove it

#### 6) Air fluid exchange:

Peripheral retina especially the inferior half is screened thoroughly for the retinal breaks which can develop due to induction of PVD. This is followed by Fluid Air Exchange. The fluid is removed by holding the extrusion needle or the cutter with suction over the disc or nasal peripapillary retina. The residual fluid can be removed from the posterior pole to ensure maximum dehydration. 30 gauge cannulas are used to directly aspirate the fluid over the region of the hole without touching the borders directly. This helps dry out the circumferential collection of fluid underlying the margins of the hole and also slowly brings about the approximation of the edges of the hole thereby reducing its size and almost making it pin point on table unless it is a chronic long standing hole.

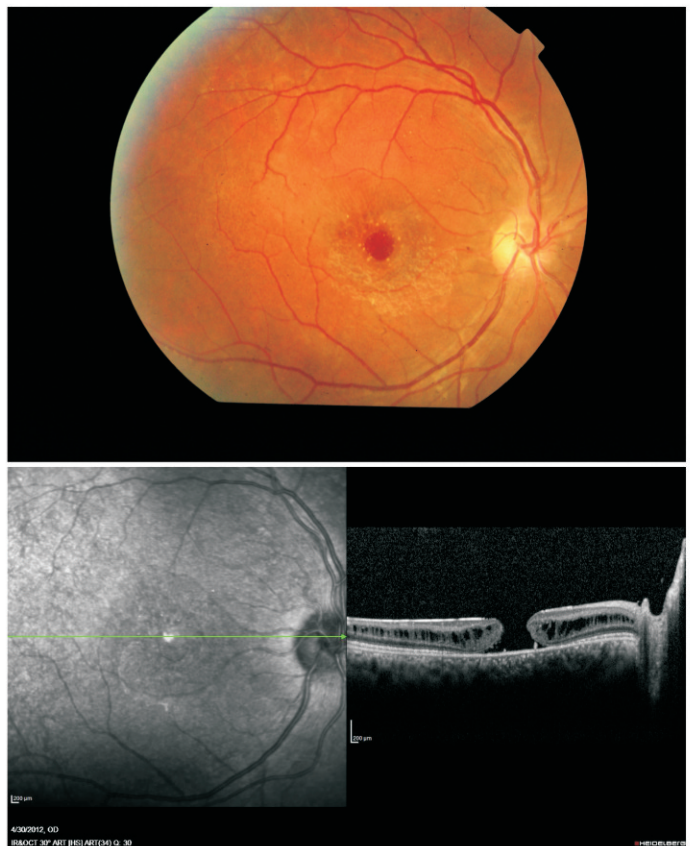
#### 7) Tamponade:

Gas is flushed to replace air with gas. We use non expansile mixture of air and C3F8 in stage 3 and 4 macular hole. Stage 2 macular holes can sometimes be managed with air tamponade.

SF6 can also be used and Silicone oil have also been used for the tamponade in macular hole cases. However use of oil is not popular as its use mandates the need of second surgery. For patients who cannot do prone positioning and for those who have a myopic degenerative holes silicon oil is a choice of tamponade

#### 8) Prone positioning:

Better success rate have been reported with better prone positioning. However there seems to be disagreement on the requirement for days of face down positioning. Most surgeons strongly request a compliance of 90 to 100% for 1 week



D 1 and D 2 Traumatic macular hole : Colour fundus photo and OCT scan

postoperatively. In spite of this the ideal duration of prone positioning remains controversial.

Some surgeons also use a portable OCT to look for hole closure on the second day and then decide further positioning. However the patient should be made aware of this prior to surgery so as to ensure maximum compliance.

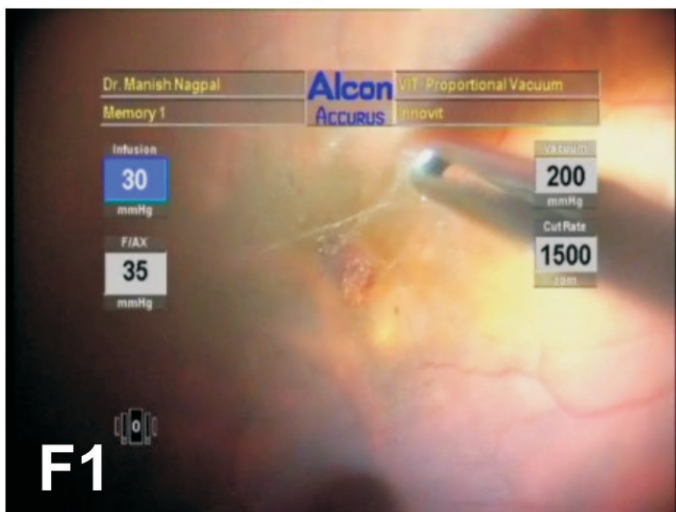
**Special adjunctive agents:** Agents like TGF-beta<sup>24</sup>, autologous serum<sup>25</sup> are reported to be used in age related macular holes. Use of platelets has been documented for paediatric traumatic macular holes<sup>26,27</sup>. A study reported that whole blood is not beneficial in closure of macular holes.

### 1. Traumatic holes:

The exact mechanism of formation of macular hole is not established. They are commonly associated with blunt trauma.



Fig. E Myopic macular hole



F1 and F2 Steps of ILM peeling in a macular hole in myopic eye

The traumatic macular holes may develop due to acute compression decompression injury associated with blunt trauma (figures D1 and D2). This leads to a localised posterior vitreous detachment at the posterior pole or avulsion of the operculum.



Most of these holes are associated with pigmentary changes around it. These pigmentary changes may develop due to Berlin's edema which develops after trauma. These holes are known for spontaneous closure. It should also be noted that longer the duration of hole, lesser the chances of closure. Therefore a 2-6 week observation period is sufficient before taking a decision of surgery for the hole closure.

### 2. Myopic holes:

Macular holes are commonly associated with myopia. These holes can also be associated with foveal schisis (figure E). The practical difficulties associated in managing such cases is the long axial length which prevents the posterior reach of the instruments, the flimsy nature of ILM which makes the staining must (figure F1, F2). The high incidence of peripheral retinal degeneration also increases the chances of retinal detachment at the time of surgery. In cases of myopic macular holes, silicone oil is used as a tamponading agent.

### Controversies:

**Membrane peeling:** Thompson et al have achieved high success rate of hole closure (94.4%) without membrane peeling.

**Tamponade:** Thompson et al observed better hole closure with 16% of C3F8 as compared to 10% and 5%. Goldbaum MH et al have reported use of silicone oil in macular hole cases.

**Positioning:** Tornambe et al have achieved the hole closure rate of 79% without any positioning but he performed meticulous dissection to remove all the epiretinal membranes.

### Complications :

In addition to the complications associated with any vitreous surgery like progression of cataract, retinal detachment, suprachoroidal haemorrhage, ERM formation, CME, endophthalmitis, there are specific complications associated with macular hole surgeries:

Sr No	Complications	Special features	Prevention
1	Changes in RPE	Three types: Facet like phototoxicity lesions, scattered stippling around the macula	Avoid prolonged exposure of the macula to the light pipe
2	Retinal breaks	Breaks occur less often near the right hand scelerotomy and more often in the temporal quadrant and inferior fundus	Thorough screening of the retinal periphery at the end of surgery
3	Visual field defect	Field defects due to,IOP fluctuation,dehydration caused by the air through the infusion canula	Control of IOP,use of humidified air for FAX
4	Reopening of macular holes	Associated with ERM, chronic holes	Meticulous membrane peeling

	Surgical pearls of vitrectomy for macular hole
1)	Stain the posterior hyaloid with TA prior to PVD induction
2)	Membrane peeling should be done under high magnification using the plano lenses
3)	ILM peeling should be done under good visualization and to stain the ILM if the surgeon prefers doing so
4)	Prior to FAX the periphery should be screened to look for any iatrogenic breaks
5)	Thorough FAX must be done ,repeat fluid aspiration from over the hole done to remove residual fluid.
6)	Light exposure to the macula should be kept to minimum

### Newer concepts:

It is known that posterior vitreous detachment occurs due to formation of fluid filled cavities inside the vitreous gel which merge with each other resulting in separation of vitreous gel from the retina. When this separation is incomplete with focal attachment to the retina, it leads to traction retinopathies. When this traction is on the macula it is termed as Vitreomacular traction (VMT). This traction induces edema ,can lead to formation of macular holes. The present day accepted norm of treatment is to keep such eyes under observation and if they become symptomatic then vitrectomy to release the traction is the preferred practice pattern. However surgery carries its own set of risk factors, and to circumvent these risk factors was the main impetus to develop an agent which can induce a complete PVD after being injected into the vitreous. It has been proposed that ocriplasmin when injected intravitreally (125 mcg) can induce PVD (pharmacologically) by targeting the fibronectin, laminin and collagen fibres which attach the vitreous to the internal limiting membrane of the retina.

### References :

- Knapp H. Uber isolirte Zerreibungen der Aderhaut in Folge von Traumen and dem Augapfel. Arch Augenheilkd 1869;1:6-29.
- Noyes HD. Detachment of retina with laceration at macula lutea Trans Am Ophthalmol Soc 1871;1:128-129.
- Campo RV, Lewis RS. Lightning-induced macular hole. Am J Ophthalmol 1984; 97:792-794
- Cohen SM, Gass JD. Macular hole following severe hypertensive retinopathy(letter). Arch Ophthalmol 1994; 112:878-879.
- Lister W. Holes in the retina and their clinical significance. Br J Ophthalmol 1924; 8:1-20
- Yoshioka H. Clinical study on macular hole3. On the pathogenesis of the senile macular hole. Acta Soc Ophthalmol Jpn 1968; 72:575-584.
- Gass JDM. Stereoscopic atlas of macular hole: diagnosis and treatments, 4th edn. St Louis: Mosby; 1996.
- Gass JDM. Idiopathic senile macular hole: its early stage and pathogenesis. Arc Ophthalmol 1988; 106:629-639.
- de Bustros S. Vitrectomy for prevention of macular hole: results of randomised multicentered clinical trial. Vitrectomy For Prevention Of Macular Hole Study Group. Ophthalmology 1994; 101:1055-1059.
- Wiznia RA. Reversibility of the early stages of idiopathic macular holes. Am J Ophthalmol 1989; 107:241-245.
- Hikichi T, Toshida A, Akiba J et al. Prognosis of stage 2 macular holes. Am J Ophthalmol 1995; 119:571-575.
- Gaurdic A, Houchine B, Massin P et al. Macular hole formation: new data provided by optical coherence tomography. Arch Ophthalmol 1999; 117:744-751.
- Johnson MW, Van Newkirk MR, Meyer KA. Perifoveal

- vitreous detachment is the primary pathogenic event in idiopathic macular hole formation. Arch Ophthalmol 2001; 119:215-222.
- 14) Spaide RF, Wong D, Fisher et al. Correlation of vitreous attachment and foveal deformation in early macular hole state. Am J Ophthalmol 2002; 133:226-229.
  - 15) Gonvers M, Machemer R, A new approach to treating retinal detachment with macular hole. Am J Ophthalmol 1982; 94:468-472.
  - 16) Croll U, Croll M. Hole in macula. Am J Ophthalmol 1950; 33:248-252.
  - 17) Harris ML, deBustros S, Michel RG. Treatment of retinal detachment due to macular hole. Retina 1984; 4: 144-147.
  - 18) Margherio RR, Schepens CL, macular breaks II. Management. Am J Ophthalmol 1972; 74:233-240.
  - 19) Jost BF, Hutton WL, Fuller DG et al. Vitrectomy in eye at risk for macular hole formation. Ophthalmology 1990; 97:843-847.
  - 20) Smiddy WE, Michels RG, Glaser BM et al. Vitrectomy for impending idiopathic macular hole. Am J Ophthalmol 1988; 105:371-376.
  - 21) Makabe R. Krypton laser coagulation in idiopathic holes. Klin Monatsbl Augenheilkd 1990; 196:202-204.
  - 22) Cox MS. Discussion of Shocket SS, Lakhanpal V, Xiaoping M et al. Laser treatment of macular holes. Ophthalmology 1988; 95:581-582.
  - 23) Gandorfer A, Rohlender M, Sethi C, et al. Posterior vitreous detachment induced by microplasmin. Invest Ophthalmol Vis Sci. 2004; 45:641-647.
  - 24) Thompson JT, Smiddy WS, Williams GA et al. Comparison of recombinant transforming growth factor beta-2 and placebo as an adjunctive agent for macular hole surgery. Ophthalmology 1998; 105: 700-706.
  - 25) Liggett PE, Skolik SA, Horio B et al. Human autologous serum for the treatment of full thickness macular holes. Ophthalmology 1995; 102: 1071-1076.
  - 26) Gaudric A, Massin P, Paques M et al. Autologous platelet concentrate for the treatment of full-thickness macular holes. Graefes Arch Clin Exp Ophthalmol 1995; 233:549-554.
  - 27) Hoerauf H, Kluter H, Joachimmeyer et al. Results of vitrectomy and the no-touch-technique using autologous adjuvants in macular hole treatment. Int Ophthalmol 2001; 24:151-159.



**Prof. P.K. Mathur**

## *Congratulations*

**Prof. P.K. Mathur** for being awarded Life Time Achievement Award by IMA Jaipur Branch and Medical Practitioner Society of Jaipur during recently held RAJMEDICON Conference 2012. He has been Past President of Jaipur Medical Association, Rajasthan Ophthalmological Society & Jaipur Ophthalmological Society. Dr. Mathur has earlier received Merit Award by Govt. of Rajasthan. He is also recipient of Gold Medal by Intraocular Implant & Refractive Surgery Society of India.