included in this study. Patients with previous and or 
coexisting diseases such as intraocular inflammation, 
ocular trauma and retinal detachment were excluded.

Patients received a complete ophthalmic examination 
including complete medical and ophthalmic history, 
best corrected Snellen visual acuity, Amsler grid testing, 
intraocular pressure measurement, slit lamp 
biomicroscopy, indirect ophthalmoscopy and OCT. 
Each patient was examined with OCT by an experienced 
examiner through a dilated pupil and macular holes 
were measured in the least horizontal diameters. 
Informed consent was obtained prior to surgical 
treatment in all patients. All surgical procedures were 
done by a single surgeon (AG) between January 2005 
and April 2006. Surgery consisted of standard 
three-port pars plana vitrectomy, peeling of the internal 
limiting membrane with subsequent intraocular gas 
tamponade using 14% perfluoropropane gas. 
Per-operatively Indo cyanine green or other dyes were 
not used to stain the internal limiting membrane. 
Internal limiting membrane was identified using Intra 
Vitreal Triamcinolone during surgery. After surgery 
patients were asked to maintain a prone position for 
14 days. Patients were examined on day 1, day 10, 
1 month, 2 months and 6 months. Postoperative OCT 
was performed at 2 months following surgery.

Anatomical success was clinically defined as apposition 
of macular hole edges and absence of sub-retinal fluid 
cuff. Anatomical success determined by OCT was 
restoration of full or partial thickness retinal reflection 
over the retinal pigment epithelium and choriocapillaries 
reflections. The primary outcome of the study was 
anatomical closure of macular hole. Parameters of 
interest were preoperative macular hole diameter, 
length of symptoms, preoperative visual acuity, Hole 
formation factor (HFF), and postoperative characteristic 
of macular hole closure as demonstrated by OCT. For 
the purpose of analysis of the primary outcome, macular 
holes were divided based on preoperative macular hole 
diameter into holes smaller than 400 µm (Group I) and 
holes equal to or larger than 400 µm (Group II). A 
secondary outcome of this study was visual acuity. 
Univariate and multivariate logistic regression analysis 
was performed. A p value of less than 0.05 was 
considered significant. Hole formation factor (HFF) 
was calculated according to Puliafito and colleagues9 
(Fig. 1). The HFF and diameters measured were 
correlated with the best-corrected postoperative visual 
acuity and visual improvement.

![Fig. 1. Optical coherence tomography of a macular hole](image)

On the basis of postoperative OCT findings, we classified 
the closed macular holes into two groups; type 1 and 
type 2 closure. Type 1 closure indicates that the macular 
hole is closed without foveal defect of the neurosensory 
etina as a U-type (Normal foveal contour); Type 2 
closure indicates macular hole is closed without foveal 
defect of the neurosensory retina as a V-type (Steep 
foveal contour). Those with foveal defect of 
neurosensory retina (W-type) were defined as open 
macular hole, an anatomical failure.

**Result**

The clinical characteristics and demographics of the 
patients are included in Table I.

There were 20 women and 3 men, with a median age 
of 63 years (Range 45 – 74 years). Preoperative macular 
hole diameter ranged from 239 µm to 1051 µm with a 
mean of 505.5 µm and a median of 487 µm. 65% of the 
eyes had a macular hole diameter greater than 400 µm. 
Preoperative visual acuity ranged from 3/60 to 6/18 
with a mean of 6/36. The median length of visual 
symptoms ranged from 6 months to 36 months. Mean 
preoperative visual acuity of the eye with a macular 
hole diameter less than 400 µm was 6/36 and mean 
preoperative visual acuity with macular hole diameter 
greater than 400 µm was 6/60. Anatomical closure of 
macular hole was achieved in 21 of the 
23 eyes (91%) with single surgery. For group I there 
was anatomical closure in all eyes. For group II, 
anatomical closure was achieved in 14 of 16 eyes 
(Figs. 2-5).
Type I macular hole closure was achieved in 14 eyes and Type II closure macular hole was observed in 7 eyes. In a subgroup analysis, Type II closure was noticed in 4 eyes in group II and in 3 eyes of group I. Type I closure was noticed in 12 of 16 eyes in group II and 4 of 7 eyes of group I. Postoperative visual acuity ranged from 6/60 to 6/9 with mean visual acuity of 6/24 (Table II).

All patients with an HFF greater than 0.7 achieved closure of macular hole whereas the 2 eyes that failed had mean HFF of less than 0.7.

### Complications

Progression of nuclear sclerosis or posterior capsular opacification occurred in all patients after the initial macular hole surgery. Transient increase in intra ocular pressure during the early postoperative period was noticed in 4 eyes. One patient had a partial rhegmatogenous retinal detachment with a horseshoe tear in the upper temporal quadrant, which was successfully managed with pneumatic retinopexy.
Surgical treatment of idiopathic macular holes had given vitreo-retinal surgeons and patients an option for visual recovery for this once untreatable condition. Although the surgical results have improved over the years, controversy still exists as regards to the exact surgical timing and also case selection.

Timing of surgical intervention, depending on idiopathic macular hole staging, size and duration has shown correlation in success rate and visual recovery. Preoperative staging has been traditionally based on the classification system proposed by Gass, judging macular hole diameter on clinical and photographic evaluation using the peripapillary vein with 125\(\mu\)m in diameter as reference. Moreover, conditions such as epiretinal membrane, lamellar macular hole, cystoid macular oedema and macular degeneration can be misdiagnosed as macular hole on biomicroscopy. OCT helps to differentiate these conditions and also assess macular hole diameter correctly. The use of OCT may allow better quantification of macular hole diameter, as OCT measurements are reproducible with a transverse resolution of 30\(\mu\)m. In our study all eyes with macular hole less than 400\(\mu\)m achieved closure.

We suggest that it is possible to use these results to conclude that smaller macular hole size attains higher rate of closure with surgical intervention. Ulrich et al have shown that preoperative measurement of macular hole size can be used as a prognostic factor for assessing anatomical success rate.

In our study 65% of eyes had an improvement of visual acuity of two or more lines. Although a trend towards greater visual acuity improvement was noticed in eyes having macular hole less than 400\(\mu\)m, this was not statistically significant (p=0.14, Wilcoxon sign rank test). However, postoperative visual acuity assessment in eyes after successful macular hole closure is affected by progression of cataract. Final visual acuity therefore should ideally be assessed after subsequent cataract surgery. Furthermore the effect of cataract was not accounted for in this study, as visual acuity data was a secondary outcome; the primary objective of this study was to correlate preoperative macular hole size with the rate of anatomical closure following vitreous surgery.

The diameter of the macular hole measured by OCT at the level of the retinal pigment epithelium seems to
provide a prognostic factor for assessing postoperative visual outcome. In our study all eyes with a macular hole diameter less than 400 µm had a final visual acuity of 6/24 or better with a mean visual acuity of 6/18. Freeman and coworkers who found that a macular hole with a smaller diameter was associated with better functional outcome have published similar results. The reason for this might be that a small hole diameter indicates better-preserved macula.

We also calculated the hole formation factor originally created by Puliafito. He considered the ratio between the overlying dimension and the hole base diameter to be of greater influence on the anatomical success rate than the base diameter alone. Puliafito found an 80% anatomical success rate in eyes with HFF greater than 0.9 and an anatomical success rate of less than 25% in eyes with HFF under 0.5. However in our study we did not find any definite correlation between HFF and incidence of macular hole closure. 69% of the eyes which achieved anatomical closure had HFF less than 0.9. One possible reason for our better success rate could be internal limiting membrane removal in all cases and a larger piece of internal limiting membrane was removed in eyes with larger macular hole diameter and low HFF.

No correlation could be found between postoperative gain in visual acuity and HFF (p=0.82). S Ulrich et al have showed similar results. Their series included 94 eyes and they found that all patients with a HFF greater than 0.9 achieved successful anatomical closure after the first surgery and the anatomical success rate was 67% in patients with HFF under 0.5. No correlation could be found between postoperative gain in lines and HFF (p=0.76) or with the base and minimum diameter (p1=0.19; p2=0.071).

Unexpectedly, the diameter of the macular hole measured with OCT was not influenced by the duration of symptoms. Therefore, large holes did not necessarily exist longer than small ones. This fact may be explained by our current understanding of the pathogenesis of idiopathic macular holes. The most favourable explanation for the development of macular hole is traction caused by focal shrinkage of the perifoveolar vitreous. Also glial cells and newly formed collagen may play an important part in macular hole formation by exerting tangential traction. The diameter of the hole therefore may depend mainly on traction forces and not on the duration of the macular hole. Another reason for the absence of correlation between the duration of symptoms and macular hole size may be the subjective estimation of the duration of symptoms by the patient. A macular hole may exist a long time before being detected.

Based on ophthalmoscopy or biomicroscopic examinations, the anatomical status of the macula after macular hole surgery was classified by Tornambe et al into three types. They suggested that flat and closed outcomes have a better visual prognosis than flat and open outcomes. Imai et al categorized the successfully repaired macular hole into three patterns with OCT: U-type (normal foveal contour), V-type (steep foveal contour), and W-type (foveal defect of neurosensory retina). The authors reported that postoperative visual acuity was well correlated with these patterns (U>V>W). The visual results obtained from the two types in our study were also similar. Because the borderline between the U and V pattern in the aforementioned study was sometimes unclear, and because the ophthalmoscopic appearance of postoperative macular hole status would be easily matched with one of the two types of closure in our study, our classification system seems more clinically relevant. Our study also found that the extent of postoperative visual improvement was greater in the case of type 1 closure than type 2 closure, but did not reach a statistical significance.

Complications of vitreous surgery for idiopathic macular hole includes retinal breaks, visual field defects, cataract formation and late reopening of the macular hole. Late reopening of macular holes has been reported in 5% to 9.5% of eyes in the previous studies. The only significant complication that we noticed in our series was a single case of rhegmatogenous retinal detachment which was managed successfully with pneumoretinopexy. There was no case of reopening of macular hole in our series.

Recent prospective studies have questioned the efficacy of adjuvants in the surgical management and visual recovery of idiopathic macular holes. In our study, we achieved anatomical success in 21/23 eyes without use of any adjuvants.

Since the mechanism of closure by vitrectomy and gas
injection is not clearly known, it is possible that relief of antero-posterior traction of hyaloid and tangential traction of Internal Limiting Membrane by surgical means with simultaneous prevention of vitreous fluid from entering the macular hole by a gas bubble may be sufficient for successful closure.

Limitations of this study are based in its retrospective nature and small sample size. Visual acuity assessment on a Snellen acuity chart is also one of the drawbacks of the study.

**Conclusion**

Preoperative measurement of idiopathic macular hole diameter using OCT may help predict postoperative anatomical and visual results. This gives the vitreoretinal surgeon and the patient a better understanding of the disease. Patients with type I closure have a better postoperative visual acuity as compared to patients with type II closure. HFF of less than 0.5 is a predictor for poor anatomical success.

**References**

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