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Novel surgical technique for macular holes with basal diameter >1000 μ

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Abstract:

Closure rate of full-thickness macular holes (FTMHs) with basal diameter >1000 μ is known to be poor. Patients presenting with FTMH having a minimum basal diameter of >1000 μ without any coexistent retinal morbidity were offered vitrectomy, internal limiting membrane peeling, retinal massage, and aspiration of subretinal fluid from the MH. Visual acuity (VA) and spectral-domain optical coherence tomography (SD OCT) assessments were performed at baseline, week 1 after surgery and at postoperative months 1, 3, 6, and 12. VA, type of hole closure, presence of ellipsoid zone, and external limiting membrane defect were monitored. The primary endpoint was type 1 anatomical hole closure. Secondary outcome measure was a change in VA from baseline to 6-month follow-up and persistent hole closure at the final follow-up of 12 months. The mean age was 67.1 ± 9.1 years. Seven eyes were pseudophakic, and two underwent combined phacoemulsification with MH surgery. The mean minimum basal diameter of FTMH was 1162.4 ± 161 μ. The mean duration of visual loss was 11.3 ± 1.93 months. Type 1 closure of FTMH was seen in all patients on SD OCT, on the 7th postoperative day. The mean presenting VA was 1.06 ± 0.1 Logarithm of the minimum angle of resolution (logMAR). Best-corrected visual acuity improved to 0.91 ± 0.09 logMAR at 1-month follow-up (P = 0.005) (95% confidence interval [CI]: 0.061–0.251), 0.63 ± 0.1 logMAR (P < 0.001) (95% CI 0.339–0.527) at 3 months, and 0.55 ± 0.05 logMAR (P < 0.001) (95% CI 0.414–0.609) at 6 months. All holes were found closed at the final follow-up of 12 months. This novel technique can help achieve better outcomes and raise the primary anatomical success rate of FTMH with basal diameter >1000 μ.

Keywords:

Internal limiting membrane peeling, macular hole, retinal massage

Introduction

Idiopathic macular holes (MHs) are a cause of loss of central vision.[1] Vitrectomy as a treatment for MH is a firmly established procedure,[2] starting with Kelly and Wendel advocating vitrectomy for MH.[3] Techniques for MH surgery have been continuously modified, leading to improved hole closure rates and better visual recovery.[2] Internal limiting membrane (ILM) peeling, in particular, has significantly improved outcomes.[2] While the prognosis of MHs has improved, the closure rate and visual outcome of full-thickness MH (FTMH) depends on the size and chronicity, with larger and chronic FTMH known to have a less favorable outcome.[4] Michalewska *et al*. reported a closure rate of 98% in large FTMH with the inverted flap technique. However, this was in FTMH with a mean hole diameter of 400 μ.[5] Availability of data on FTMH above 1000 μ basal diameter is scarce. Khodani *et al*. in their study with idiopathic MHs above 1000 μ found that the inverted flap technique could not achieve type 1 closure in all patients in their series.[6] Other reported techniques include the use of a free ILM flap, autologous lens capsular flap, and autologous neurosensory retinal flap.[2,7,8] Mobilization of MH edges in promoting the closure of chronic and large MHs has

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been described.[9-11] Induction of macular detachment to facilitate mobilization of the retinal tissue around MHs for better apposition has also been reported.[10,12]

Although each of these surgical approaches has had some success, they remain technically challenging and can be improved upon. We present a novel technique using retinal massage and passive fluid aspiration from the MH that ensures the closure of MHs with very large (>1000 µ) basal diameter.

Materials and Methods

This observational study was conducted at two tertiary eye care facilities in India from January 2022 to December 2022. The study was approved by the Institutional Review Board of Disha Eye Hospitals (Registration Number ECR/846/Inst/WB/2016/RR-19: EC-CT-2022-138) and was conducted as per the tenets of the Declaration of Helsinki, Good Clinical Practice guidelines, and International Council for Harmonization. Informed consent was obtained from all participants before the commencement of surgery. Patients presenting with very large FTMH defined as having a minimum basal diameter of >1000 µ (average of horizontal and vertical scan) without any coexistent retinal morbidity were offered surgery with vitrectomy, ILM peeling, retinal massage, and aspiration of subretinal fluid from the MH. Eyes with MHs secondary to trauma, high myopia (axial length >26 mm), retinal detachment (RD), retinal surgeries, and recurrent or persistent MHs were excluded from the study. Data of consecutive patients meeting inclusion criteria with a minimum of 1-year follow-up were drawn up from a computerized database. Patient demographics such as age, gender, baseline best-corrected visual acuity (VA), duration of vision loss, axial length, and maximum basal diameter of MH on spectral-domain optical coherence tomography (OCT) scans (Optovue Inc., Fremont, CA, USA) were recorded before MH surgery. VA was recorded and OCT scan performed at week 1 after surgery and subsequently at postoperative months 1, 3, 6, and 12. VA improvement, type of hole closure, presence of ellipsoid zone (EZ) defect, and external limiting membrane (ELM) were monitored.

Outcome measures: the primary endpoint was type 1 anatomical hole closure[13] rate at 1 month postoperatively. Any eye with a persistent neurosensory defect or type 2 closure[13] was considered a failure. The secondary outcome measure was a change in VA from baseline at 6-month follow-up and persistent hole closure at the final follow-up of 12 months.

Surgical technique

The surgeries were performed under peribulbar anesthesia using 25G vitrectomy systems (Constellation, Alcon, USA) by five fellowship-trained vitreoretinal (VR) surgeons (DC, SM, SS SB, and AD). After making three pars plana vitrectomy ports, a core vitrectomy was completed, posterior vitreous detachment was induced from the optic disc using diluted triamcinolone acetonide. ILM was stained using brilliant blue dye (Auroblue BBG, Aurolab, Madurai, India), and ILM peeling was initiated in the peripapillary region using ILM grasping forceps (Greishaber, Alcon, USA). ILM peeling was carried out over an area measuring 2 disc diameters around the fovea, with peeling carried out across the edges of the MH to ensure the release of all tangential traction. The retina was then massaged in a centripetal direction, i. e., radially, superior and inferior to the MH, in order to try and approximate the edges of the hole into a slit. This was followed by fluid–air exchange and finally, aspiration of residual fluid from the center of the MH using the same 27G soft-tipped cannula, leading to a significant reduction or closure intraoperatively of the MH [Figure 1 and Supplementary Video 1]. Care was taken to aspirate the residual fluid from the edge of the hole and not from the base so that the tip of the silicon-tipped cannula did not touch the retinal pigment epithelium at the base of the hole. Finally, air was

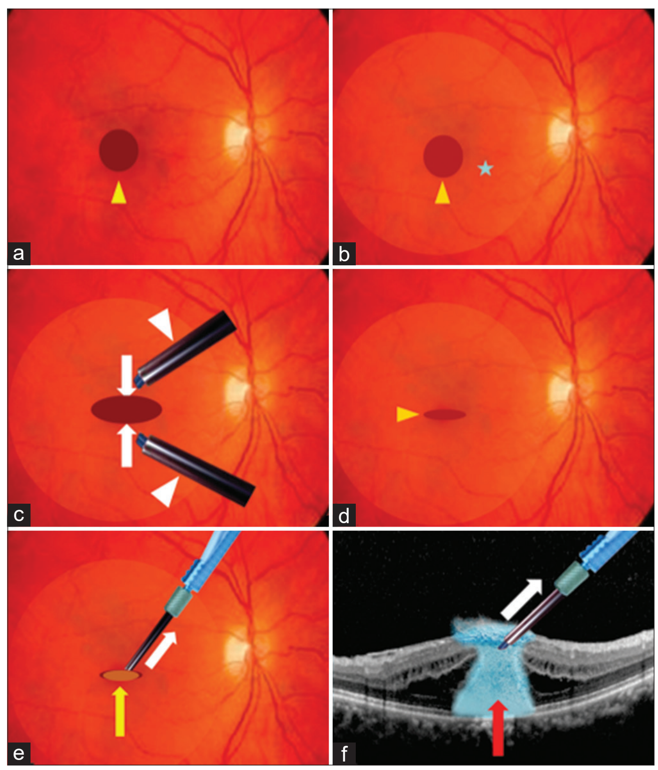

Figure 1: Illustrative image of the surgical procedure. An eye with full-thickness macular hole (yellow arrowhead) (a), the internal limiting membrane is peeled (blue asterisk) (b). Radial massage (white arrows) is done superior and inferior to the macular hole (white arrowheads) (c). The edges of the macular hole (yellow arrowhead) are seen to be approximated (d). During fluid-air-exchange, fluid within the macular hole (yellow arrow) is aspirated from the edge of the hole (white arrow) (e). Cross sectional image demonstrating the fluid (red arrow) being aspirated from the edge of the hole (white arrow) (f).

replaced with 14% C3F8 gas, cannulas were removed, and intraocular pressure was checked. Intraoperative assessment included careful documentation of any intraocular complication on the table.

Patients were advised to maintain face-down position for 7 days after surgery.

Results

Nine eyes of nine patients fulfilling the inclusion criteria were included in the study. The mean age of patients was 67.1 ± 9.1 years. There were seven females in the study group. Seven patients were pseudophakic and two underwent combined phacoemulsification with MH surgery. The median axial length of the study eyes was 23.9 mm ± 0.41. The mean minimum basal diameter of the MHs was 1162.4 ± 161 μ.

Type 1 closure of MH was seen in all patients on spectral-domain (SD) OCT, on the 7th postoperative day [Figure 2]. The mean presenting VA was 1.06 ± 0.1 logarithm of the minimum angle of resolution (logMAR). The mean duration of visual loss was 11.3 ± 1.93 months. VA improved 0.91 ± 0.09 logMAR at 1 month follow-up (P = 0.005) (95% confidence interval [CI]: 0.061–0.251). At 3-month follow-up, there was further improvement to 0.63 ± 0.1 logMAR (P < 0.001) (95% CI 0.339–0.527). VA improved further 6 months 0.55 ± 0.05 logMAR (P < 0.001) (95% CI 0.414–0.609). The vision did not improve further at the 12-month time point [Table 1].

The proportion of eyes with persistent EZ defect reduced gradually from 8/9 at 1 month to 5/9 at 6 months and 12-month follow-up. At 12 months, 2/9 eyes still demonstrated an ELM defect. In terms of closure type, the U-shaped closure was noted in three eyes and V-shaped closure in six eyes. No complications were noted in the immediate postoperative period and up to 1-year of follow-up. None of the eyes experienced hole reopening during the follow-up period.

Statistical analysis

Statistical analyses of the results were conducted using Student's t-test. P =0.05 was considered statistically significant. All statistical analysis was performed with GraphPad Prism San Diego, CA.

Discussion

We found that vitrectomy with ILM peeling, retinal massage, passive aspiration of subretinal fluid from the hole, and gas tamponade with face-down positioning lead to 100% type 1 closure in eyes with MHs >1000 μ. Visual improvement continued to occur over 6 months after surgery, following which the vision stabilized. In our series of nine eyes, review of recorded videos of all patients demonstrated that there was a change in the rounded taut contour of the MH to a crenated slit-like

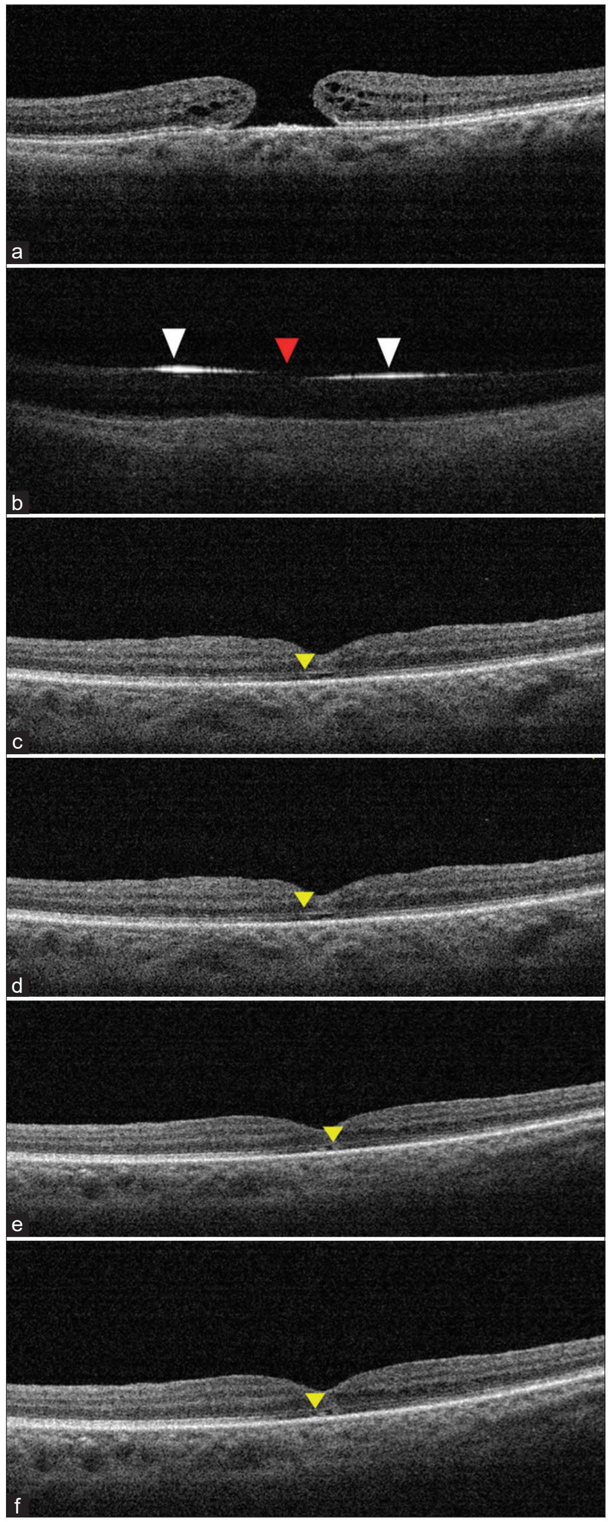

Figure 2: Representative images of optical coherence tomography of an eye with full-thickness macular hole (a), 1-week postsurgery with closed macular hole in red arrowhead and the gas–retina interface in white arrowhead (b), 1-month postsurgery where initial development of the ellipsoid zone can be seen in the closed hole in yellow arrowhead (c), further growth of the ellipsoid zone (in yellow arrowhead) is evident in the images at 3 months (d), 6 months (e), and 1 year (f) following surgery

Table 1: Demography

Serial number	Age	Sex	LogMAR					Duration of complaint (months)	MH diameter at baseline
			Preoperative VA	1-month VA	3-month VA	6-month VA	12-month VA		
1	59	Female	1.2	1	0.6	0.5	0.5	9	1012
2	68	Female	1	1	0.6	0.6	0.6	12	1302
3	83	Male	1.2	1	0.8	0.6	0.6	9	1028
4	59	Female	1	1	0.8	0.6	0.6	13	1203
5	73	Female	1	0.8	0.6	0.5	0.3	12	1020
6	79	Male	1	0.9	0.6	0.6	0.6	13	1468
7	60	Female	1	0.9	0.5	0.6	0.6	14	1267
8	62	Male	1.2	0.8	0.6	0.5	0.47	11	1143
9	62	Male	1	0.8	0.6	0.5	0.47	9	1019
Mean±SD	67.1±9.1		1.06±0.1	0.91±0.1	0.63±0.1	0.55±0.05	0.52±0.1	11.3±1.93	1162.4±161

VA=Visual acuity, SD=Standard deviation, LogMAR=Logarithm of the minimum angle of resolution, MH=Macular hole

appearance of the edges following "retinal massage" and also apposition of the hole edges intraoperatively following fluid–air exchange and drainage of subretinal fluid from the MH [Supplementary Video 1].

Traditional PPV has been reported to achieve a successful closure rate in excess of 90% of FTMHs,[2,14] but only 50% to 70% in large FTMHs.[15,16] While ILM peeling facilitates the removal of tangential tractional forces on the MH edges and enhances overall retinal compliance by restoring the neurosensory retina's intrinsic elasticity,[2] the use of inverted ILM flap by Michalewska *et al*. is hypothesized to stimulate proliferation of glial cells that fill MHs, thereby enhancing closure.[6]

Bringing together of the MH edges have been tried by various authors.[9-19,21] While Wong described manual massage of the retina using Tano's silicone-tipped scraper to maneuver the retina radially to approximate the edges of the MH,[10] Alpatov *et al*. used a blunt VR spatula to flatten the macula from periphery to center. In addition, they used a vitreoretinal forceps to mechanically approximate the edges of the hole in their technique, followed by fluid–air exchange and gas tamponade.[16] Our technique appears to be similar to this but much less traumatic since we use 25G instrumentation and also a 27G soft silicone tip cannula to perform the retinal massage.

Felfeli and Mandelcorn,[17] Mohammed and Pai,[18] Claes,[19] and others injected fluid under the retina, thereby creating a localized RD to ensure that the retina became more pliant, facilitating bringing together of the MH edges. Claes reported subretinal fluid drainage through the MH after initially producing a RD in recurrent MHs with good anatomical success.[19] We observed that gentle massage using a 27G soft-tipped cannula was sufficient for mobilization of the retina around the MH and bring about an approximation of the edges of the hole. Additional procedures such as induction of RD, described by others[16-19] were not necessary.

Kang *et al*. noted in the case of very large MHs, glial bridging or plugging of the relatively large neural defect might be harder.[13] Bringing together the hole edges may facilitate closure in these large holes, as has been noted by various groups.[9-11,19,20] Subsequent passive extrusion of the fluid within the MH during fluid–air exchange assists in partial to complete intraoperative apposition of the MH. The additional step is technically straightforward, as described by our group previously, for holes with a mean diameter of up to 835 μ.[20] Keeping the MH dry has been described as one of the most important factors to achieve MH closure.[21] We believe the combination of bringing the edges together and drainage of the MH fluid kick-starts hole closure as was evident even at 1 week in all nine eyes with very large MH >1000 μ. Our study has more than 12-month follow-up, and during this period, we have not noted any complications such as retinal pigment epithelial mottling, RD, or reopening of MHs.

In addition to improving the primary success rates of surgery in large FTMHs, this technique is unique, in that, it combines the removal of ILM, eliminates any residual tractional forces, and apposes the hole edges without the use of any adjuvants. Furthermore, dislodgment of flap, adjuvant retinal tissue, lens capsule, etc., as used by others, were not a point of concern. However, it is important to note that successful closure of the MH does not always guarantee optimal visual outcomes, as visual recovery can vary depending on several factors, including the size, chronicity, and location of the MH, as well as other individual patient factors.

Limitation of our study includes a small number of eyes and also the retrospective nature of the series. However, the success of the five surgeons adapting easily may highlight the ability of this technique to be quickly learned and mastered by other VR surgeons. Wider use of this technique may help achieve better outcomes and raise the primary success rate of very large FTMH closures to levels comparable with smaller FTMHs.

A large comparative case series may further help to more comprehensively examine the benefits of this technique.

Summary statement

Techniques for MH surgery have been continuously modified, leading to improved closure rates and visual recovery. The closure rate and visual outcome of full-thickness macular holes (FTMH) depend on the size and chronicity, with larger and chronic FTMH known to have a less favorable outcome. Availability of data on FTMH with a basal diameter above 1000 μ is scarce. No technique thus far has been able to achieve 100% closure in macular holes with a basal diameter >1000 μ. We present a novel technique using retinal massage and passive fluid aspiration from the macular hole that ensures the closure of very large (>1000 μ) full-thickness macular holes.

Data availability statement:

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Nil.

Conflicts of interest

The authors declare that there are no conflicts of interests of this paper.

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