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Research Article

Inverted ILM Flap Technique: Efficacy in Large Macular Hole Surgery (A Prospective Comparative Study of 70 Cases)

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Abstract

Purpose: To evaluate the efficacy of inverted internal limiting membrane (ILM) technique for large macular holes (MHs) (> 400 µm) and to compare the anatomical and functional outcomes with the standard technique.

Material and Methods: Comparative prospective study on 70 cases separated into two groups, group 1 of 39 patients were operated with ILM peeling and in group 2, 31 eyes underwent a modification of the standard technique, called the inverted internal limiting membrane (ILM) flap technique.

Results: The mean age of patients was 60.4 years. Mean postoperative BCVA, patients in both groups showed a statistically significant improvement in visual acuity (p:0.37). The closure rate of macular hole was 98%. The diameter of macular holes varied between 400 - 1100 µm. DONFL were observed in 10 patients in group 1 versus 7 patients in group 2.

Conclusion: We observed that visual acuity improvement rate after reverse ILM technique was higher but the anatomical outcome for large MH was achieved using both techniques.

Keywords: Macular Hole Surgery; Inverted ILM Flap; ILM Flap

Introduction

A macular hole (MH) is an anatomical defect in the fovea, with a prevalence rate ranging from 0.2% to 0.7% in the general population [1,2]. This condition predominantly affects patients older than 65 years, with two-third of patients being women.

Large MHs are defined as having a diameter >400 mm, based on the horizontally measured linear width at the narrowest point of the hole. Large MHs have been reported to remain open after primary repair in up to 44% of cases. Retinal surgeons have since been refining and developing novel surgical techniques for large MH, which less likely to close after a standard PPV or PPV combined with peeling of the ILM [1].

In 2010, an innovative technique called "reverse ILM" flap technique "was described by Michalewska, it was recommended as an effective surgical procedure for the treatment of idiopathic large MHs and high myopia [2].

It is a recent technique which seems to prove its effectiveness with a higher rate of closure, proposes a peeling limited to the temporal flap to limit iatrogenic trauma: functional alteration of Muller cells, decrease in retinal sensitivity, abnormalities of the retinal surface (SANFL and DONFL).

Material and Methods

We carried out a comparative, prospective study of 70 patients affected by idiopathic large macular hole as determined by bio microscopy and optical coherence tomography (OCT) imaging, who underwent a surgical treatment at Nour Ophthalmology Clinic of Casablanca in Morocco, between June 2022 and June 2023.The exclusion criteria included: Diameter of MH <400µm, post-traumatic MHs or associated with retinal detachment or diabetic retinopathy.

At baseline and at every follow-up visit (1 month, 3 months and 6 months after surgery), all patients underwent a complete ophthalmologic examination, including measurement of the BCVA, slit-lamp examination and biomicroscopy. BCVA measured with a Snellen chart was converted to logarithm of minimum angle of resolution (LogMAR) for statistical analysis. MH diameter and outer retinal layers were evaluated at the same time by SD-OCT. To evaluate the surgical effects, the preoperative and postoperative BCVA (logMAR value) were analyzed using the paired t test. A P value of <0.05 was considered significant.

All eyes had undergone 23 or 25-gauge pars plana vitrectomy (PPV) followed by conventional ILM peeling combined with C2F6 gas (perfluoroethane) tamponade was conducted in Group 1: ILM peeling group, while PPV with inverted ILM flap technique and C2F6 gas tamponade was performed in Group 2: ILM flap group.

Surgical technique

- **Group 1:** A triamcinolone acetonide-assisted posterior vitreous detachment induction was made in 25% of cases and a staining of ILM using brilliant blue-dye was used in 40%, the ILM was peeled off centripetally, approximately 2 disk diameters around the MH. At the end of the surgery, the eye was filled with perfluoroethane (C2F6, 16%). The patients were instructed to maintain a face-down position for 7 days.
- **Group 2:** Using Grieschaber forceps, the ILM peeling was performed in a circular motion for approximately 1 disc diameters and then dissected for 2 disk diameters around the macular hole, so that the ILM was not removed completely from the retina but left attached to the edge of the macular hole making the flap large enough and allowing it to crease and fold on itself in any orientation to reverse it on the macular hole in 25 cases [Figure 1]. PFCL was used for preventing the detachment of inversed ILM until the fluid-air exchange is complete then the inverted flap was held in place with intraocular gas (C2F6).

Results

On a total of 70 patients, thirty-nine eyes of 39 consecutive patients were treated for large MHs according to the standard technique (PPV, ILM removal and C2F6 gas tamponade) (Group 1) and thirty-one eyes of 31 consecutive patients were operated with inverted ILM flap technique (Group 2). Demographic data and variables are shown in [Table 1].

Figure 1: A QR code showing the per-operative ILM flap technique.

	Group A (ILM removal)	Group B (Inverted ILM flap)	p
Age (mean ± SD)	67.41 ± 13.54	61.54 ± 7.32	0.17
Diameter of MH (µm, mean± SD)	715 ± 138	690.86 ± 74.96	0.097
Gender (H/F)	9 (31%)/20 (69%)	7 (28%)/18 (72%)	0.51
Pre-operative lens status : Phakic Pseudophakic	 55% 45%	 55% 45%	 0.76 0.76

Table 1: Demographic and clinical profile of patients.

The mean age was 60.4 years (range 42-76 years) and female gender represents 70.3% of all patients recruited. The same proportion of eyes had undergone simultaneous phacoemulsification along with macular hole surgery and the ratio of pseudophakic eyes was 45% in both groups.

There were no statistically significant differences in age groups (P value = 0.17) or preoperative BCVA (P value = 0.48). The mean minimum diameter of the MH was higher in the inverted ILM flap group, but the difference was not statistically significant (peeling group A: 565.09 ± 164.68 µm; ILM flap group B: 639.33 ± 172.36 µm, p value = 0.09).

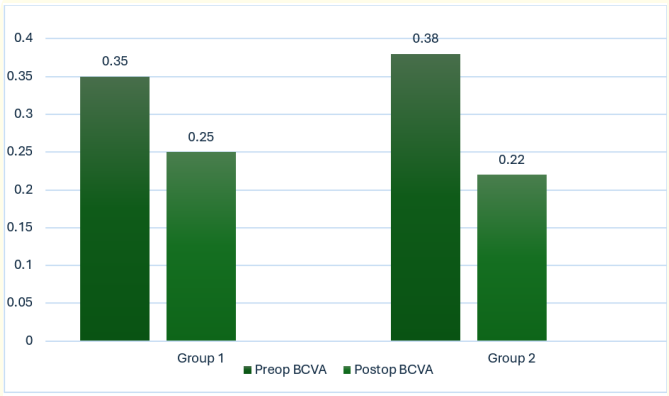
The procedure was considered effective if complete closure of the MH was obtained (defined as the absence of a neurosensory defect over the retina). At 3 months of follow-up, SD-OCT showed MH closure in 36 cases in Group 1 (92.3%) and 29 cases in Group 2 (93.5%) after one single surgery.

Three surgical failures occurred in the Group 1, an additional surgery was performed for two patients. In Group 2, there were 2 surgical failures. One of these patients was reoperated and presented a MH closure after a 6-month follow-up.

The primary MH closure rate was 97.4% (36/39) in Group 1 and 96.7% (29/31) in Group 2 (*P*-value = 0.67). However, the final MH closure rate reached 98% in both groups after the reoperation.

Regarding the OCT aspect, we observed that the temporal inverted flap technique is associated with a lower incidence of dissociated optic nerve fiber layer (DONFL). Indeed DONFL were observed in 8 patients in group 1 versus 5 patients in group 2 [Figure 2, 3].

Patients in both groups showed a statistically significant improvement in visual acuity. The mean postoperative BCVA at 6 months was 0.25 ± 0.17 in group A and 0.22 ± 0.14 in group B (p: 0.37) [Graphic 1]. Statistical analysis confirmed that there was no significant difference in visual acuity between the two groups at postoperative visits (t-test).



Graph 1: Mean pre-operative and post-operative BCVA (logmar).

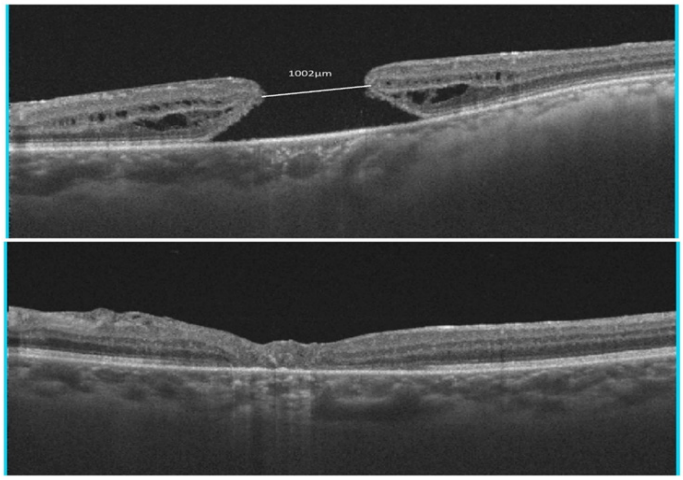


Figure 2: A 65-year-old female presented with idiopathic large MH. The minimum diameter was 1002 µm. Preoperative BCVA was 0.04. Inverted ILM flap technique was performed, with a W-shape closure of the MH as shown in SD-OCT at 4 month postoperatively. BCVA was 0.16.

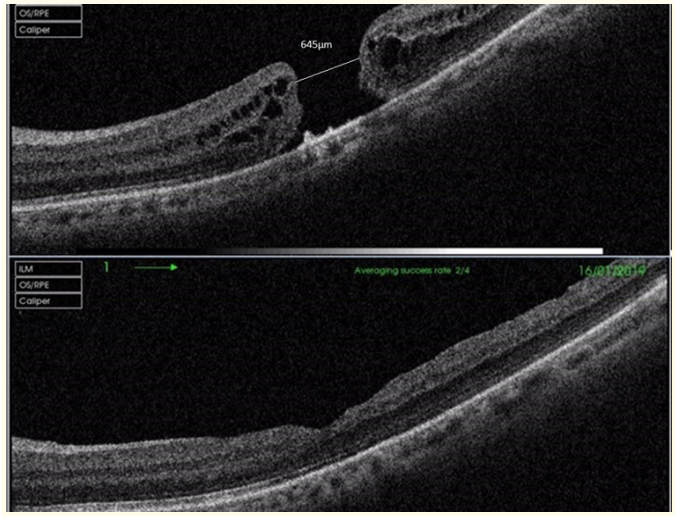


Figure 3: Pre-operative and postoperative OCT scan at 4 months follow-up of a -year-old male patient operated on using ILM technique (group 1).

Discussion

Full-thickness macular hole is an anatomical defect in the fovea with interruption of all neural retinal layers. It has shown that anteroposterior traction does not appear to be the only mechanism for MH formation, tangential traction plays an important role in MH progression and recurrence, activated glial cells, especially Muller cells and astrocytes, can proliferate and migrate to form lateral epiretinal cells and generate tangential traction [3].

Surgical management of MHs was pioneered by Kelly and Wendel in 1991 who reported the closure of a macular hole after a vitrectomy by removing all anteroposterior traction, this represented a turning point in the approach of the MH disease [4].

For years ILM peeling has been the go-to standard surgical procedure in small MHs allowing close rates of close to 100% [5]. However, macular holes, larger than 400 µm, have an increased risk of failure, with a non-closure rate of 19%. Michalewska., *et al*. introduced the temporal inverted ILM flap technique by decreasing the area of ILM peeled and thereby minimizing iatrogenic trauma associated with ILM peeling. In this technique, the ILM peel is started temporal to the MH and covers an area of approximately two disk diameters [6].

Sborgia and al. reported a high anatomical closure rate of 98% by using the inverted ILM-Flap technique, which has been reported to have a high closure rate of large macular hole [7,8]. The ILM-flap might work as a scaffold for the proliferation and migration of activated Müller cells that promote the closure of macular hole producing neurotrophic factors [9]. This technique leads to an acceleration of the wound healing processes at the macula.

The macular hole closes, possibly due to the fusion of the ILM with structures at the edges of the hole. The retinal epi cells present on the vitreous side of the ILM form micro fibrils which contribute to the process of MH closure [10], and this flap serving as a matrix allows the migration of photoreceptors. Recently, the use of viscoelastic or PFCL has been effective in preventing the detachment of inversed ILM until the fluid-air exchange is complete [11].

Ramtohul and al. showed that reconstruction of the foveal ELM 3 months postoperatively helps predict subsequent restoration of the ellipsoid zone and the potential for better visual outcomes. Restoration of both ELM and EZ was significantly higher with the inverted ILM flap technique [12].

Our anatomical and functional results do match with the data in the literature and showed the superiority of the reverse ILM technique compared to standard conventional surgery concerning visual acuity but the rate of closure was identical for both techniques. This discrepancy may be related to the presence of bothersome cataracts in 45.83% which could underestimate the real gain in visual acuity.

SANFLs (Swelling of the Arcuate Nerve Fiber Layer) correspond to the gripping areas of a peeling that is often traumatic. The edema of the nerve fibers then gradually disappears. There then persists in this area a sequellar thinning of the optical fibers often associated with the persistence of micro-scotomas [13,14].

DONFL (Dissociated Optic Nerve Fiber Layer) is associated with the peeling of the internal limiting membrane (MLI). It then appears many arciform streaks in the direction of the optical fibers [15]. Its appearance is later (1 to 3 months after surgery) than SANFL but remains visible in the long term. DONFL do not seem to be associated with less functional recovery. The hypothesis put forward to explain DONFL would be that the mechanical tractions performed during the peeling of the MLI would cause a dissociation of the bundle of nerve fibers damaging the Muller cells which hold the fibers together [15-17].

The limitation of our study are the small sample size and the lack of evaluation of micro scotoma in micro perimeter and absence of OCT at day 15 to visualize the kinetics of integration of the ILM into the underlying tissues.

Conclusion

In summary, large macular holes with a minimum diameter of 400 µm present surgical challenges and have a poorer than average anatomical prognosis. The inverted-flap and free-flap techniques represent alternative surgical options that may lead to a better anatomical outcome. Our results indicate no difference between these techniques concerning the closure success. However, patients assigned to the inverted-flap group demonstrated a better functional outcome.

Larger randomized studies with a control group are needed to establish the real role of this technique in MH refractory to conventional surgery.

Histological studies as well as the OCT can provide important information on the actual healing mechanism and the mechanics of integration of the IL component.

The authors declare no conflicts of interest.

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