**Pedicle internal limiting membrane flap technique for large macular holes: A 4-case series**

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**Abstract**

Purpose

To report the anatomical and functional outcomes of 4 large macular hole cases submitted to the pedicle ILM flap technique

Methods

This is a retrospective series of four patients with large macular hole who were treated with the pedicle internal limiting membrane technique. Comprehensive ophthalmologic evaluation was performed before surgery and included ETDRS best-corrected visual acuity (BCVA) and SD-optical coherence tomography (SD-OCT) for macular hole measures: MH height, minimum linear diameter (MLD) and external base diameter. The particular detail of this technique is related to ILM flap creation. During the peeling, the ILM was not removed completely from the retina but was left attached to the edges of the macular hole, and subsequently trimmed with the vitrectomy probe using the scissors mode.

### Results

We reported here patients operated with the inverted ILM pedicle flap technique for large MH (>700 μm). Of the 4 cases reported, 3 obtained anatomical closure (75%), and aso presented Best-corrected visual acuity (BCVA) improvement after surgery, considering the last follow-up visit of each case. No additional procedures were performed in either case. One patient demonstrated no anatomic and functional improvement.

Conclusion

The present study describes the first Brazilian case series of large MH treated by the inverted pedicle IML flap technique. This technique was associated with anatomic and visual improvement in most cases, and represents an alternative therapeutic approach for large macular holes

**Introduction**

A macular hole is defined as a full thickness retinal break caused in most cases by vitreoretinal traction.1

The prevalence of idiopathic macular holes ranges from 0.02%2 to 0.33%3 or 0.7%4, being 4 in 1000 in the population aged 63-102 years.5 A study conducted in Minnesota (US) detected an incidence of 7.8 per 100 and per year, with a 3.3/1 female/male ratio6. Studies on Asian populations have reported rates of 0.09 and 0.17% 7,8. Age of 65 years or older and female sex are the relevant systemic risk factors identified thus far9,10. Bilateral involvement varies considerably from 5 to 16%11-13.

The role of the vitreous in this disease and its classification started to be understood by Gass with the use of posterior segment biomicroscopy13-15. However, it was only with optical coherence tomography that it became possible to better study vitreoretinal traction and macular holes16. A good visualzation of the vitreoretinal interface permitted the introduction of the concept of vitreomacular adhesion (adhesion with no change in retinal architecture) and vitreomacular traction (adhesion generating anatomical changes), as well as the subdivision of hole size (shortest distance between its margins) into small (<250 μm), medium (250-400 μm) and large (>400 μm). This classification also includes information about a primary or secondary etiology (high myopia, trauma, among others) 17.

Macular holes were considered to be untreatable before the 1991 pioneering study of Kelly and Wendel18 who developed a surgical technique capable of closing a macular hole with good anatomical and functional results. With the technical and instrumental progression over the years, pars plana vitrectomy has become the gold standard, with posterior vitreous detachment with or without peeling of the internal limiting membrane (ILM) and gas buffering, permtting the closure of 85% to 90% of the cases19.

For macular holes measuring more than 500 µm, the final visual acuity usually is less than 0.2 and reoperations are often necessary.20.21. The variation in the type of postoperative macular hole closure is another factor influencing the lack of anatomical success. After primary repair by the standard technique, large macular holes remain open in up to 44% of all cases.22 Thus, surgical alternatives are being developed for holes >400 μm, such as ILM peeling with an inverted flap23 in order to improve the anatomical and functional results.

The therapeutic options for small and medium holes are being extensively revised. Due to the lack of randomized clinical assays with an appropriate sample, there is still no consensus for large, recurrent or persistent holes.24

The objective of the current report was to present a series of 4 cases subjected to the pedicle ILM flap technique with the description of anatomical and functional aspects.

**Methods**

This is a retrospective series of four patients with large macular hole who were treated with pedicle ILM flap technique , between May 2018 and May 2019.

Comprehensive ophthalmologic evaluation performed at baseline and postoperative following PPV included ETDRS best-corrected visual acuity (BCVA); MH height, minimum and maximum hole diameters measured by spectral domain optical coherence tomography (OCT) (Heidelberg, Germany). According to the Internationl Vitreomacular Traction Study (IVTS)17, all 4 cases reported here were classified as having a large full thickness macular hole, i.e., a hole with a distance of more than 400 µm between the closest marging of the retinal gap.

Before surgery, all eyes were dilated with two drops of 10% phenylephrine eyedrops administered 5 mins apart and three drops of 1% tropicamide eyedrops administered 3 mins apart . The initial treatment was provided by the same surgeon in an surgical environment under aseptic conditions and with topical anesthesia.

A three-port PPV , core vitrectomy and trypan blue staining were performed. If an epiretinal membrane was present, it was peeled. The ILM was peeled around the macular hole. During the peeling, the ILM was not removed completely from the retina but was left attached to the edges of the macular hole. The ILM flap remains attached to the macular hole edge and is trimmed with the vitrectomy probe using the scissors mode.

**Case Series**

**Case 1**

A 67-year-old woman with a progressive low visual acuity complaint in the right eye starting approximately 8 months ago. Ophthalmological examination revealed BCVA of 1.3 logMAR (20/400 snellen) in right eye (OD and 0 logMAR (20/20 snellen) in the left eye (OS). Preserved direct and consensual pupillary reflexes and normal applanation tonometry in both eyes . Slit lamp biomicroscopy shows a topical intraocular lens (IOL) in OD. Eye fundus examination revealed a grade 4 macular hole (MH) according to Gass4, confirmed by optical coherence tomography (OCT), which showed a full thickness MH with a minimum diameter of 748 μm and and a height of 368 μm (FIG 1A). No changes in OS. The following procedures were performed: prophylactic 360º laser in OD, pars plana vitrectomy, epiretinal membrane and ILM peeling, and confection of an inverted pedicle ILM flap of OD( FIG 2 A-C).. Five months after the intervention, the patient showed BCVA of 1.0 logMAR (20/200 snellen) in OD, with full MH closure detected by fundoscopy and OCT (FIG 1 B).

**Case 2**

A 70-year-old woman with progressive low visual acuity in OD for 1 year, with no previous eye surgeries. Initial examination revealed BCVA of 1.3 logMAR (20/400 snellen) in OD and 0.5 logMAR (20/63 snellen) in OS. Slit lamp examination shows moderate cataract in OD. Fundoscopy revealed a grade 4 MH in OD. OCT showed a full thickness MH with a minimum diameter of 811 μm and a height of 444 μm (FIG 3 A). No changes in OS. The following procedures were indicated: phacoemulsification, pars plana vitrectomy, epiretinal membrane and ILM peeling and confection of an inverted pedicle ILM flap of OD. Six months after the procedure, the patient showed BCVA of 0.9 logMAR (20/160 snellen) in OD, with fundoscopy and OCT revealing full MH closure (FIG 3 B).

**Case 3**

A 72-year-old man with progressive low visual acuity inOD starting 5 years ago. BCVA was 1.3 logMAR (20/400 snellen) in OD and 0.3 logMAR(20/40 snellen) in OS. Slit lamp examination shows moderate cataract in OD. Fundoscopy revealed a grade 4 MH in OD (FIG 4 A) . OCT showed a full thickness MH with a minimum diameter of 768 μm and a height of 388 μm (FIG 4 B). No changes in OS. The following procedures were indicated: phacoemulsification, pars plana vitrectomy, epiretinal membrane and ILM peeling and confection of an inverted pedicle ILM flap of OD. Five months after the procedure, the patient had BCVA of 1.0 logMAR (20/200 snellen) in OD, with full MH closure determined by fundoscopy and OCT.(FIG 4 C).

**Case 4**

A 76-year-old woman with superior visual field reduction in OD starting 1 month ago. BCVA was 1.2 logMAR (20/320 snellen) in OD and 0.1 logMAR (20/25 snellen) in OS. Slit lamp examination shows topical crystalline in both eyes. Fundoscopy revealed a grade 4 MH in OD. OCT showed a full thickness MH with a minimum diameter of 755 μm and a height of 483 μm (FIG 5 A, B).No changes in OS. The following procedures were indicated: phacoemulsification, pars plana vitrectomy, epiretinal membrane and ILM peeling and confection of an inverted ILM pedicle flap of OD**.** Five months after the procedure, the patient had maintained BCVA of 1.2 logMAR (20/320 snellen) in OD and a maintained MH of width and thickness similar to baseline values (FIG 5 C).

**Discussion**

Kelly and Wendel 18 described the conventional MH surgery, but modifications have been made over the years providing better visual and anatomical results, especially for large or recurrent holes. One of these modifications was reported by Michawleska et al who used a pedicle ILM flap to close macular holes, a similar techinque employed in our case series. We reported here patients operated with the inverted ILM pedicle flap technique for large MH (>700 μm). Of the 4 cases reported, 3 obtained anatomical closure (75%). Michawleska et al23, in a comparative study of two groups – one of 51 eyes submitted to standard pars plana vitrectomy and the other of 50 eyes submitted to the pedicle inverted ILM flap - obtained closure of the MH in 88% of the patients in the conventional group and in 98% of the patients in the other group. Plane and open postoperative appearance was observed in 19% of group 1 patients and in 2% of group 2 patients.

Studies by Michalewska et al20 and Imai et al21 have shown that the form with the best and more prevalent functional result (45%) is U-shaped closure, followed by V-shaped closure and W closure (irregular,19-39%), with the last type showing a worse functional result even in the presence of a favorable anatomical result. In the present study, we performed 2 V-shaped closures and 1 U-shaped closure. In the V-shaped cases, BCVA improved one and two lines of visual acuity, respectively , while in the U-shped closure, BCVA improved one line of visual acuity.

Another important factor for final BCVA, i.e, preserved functionality after closure of the MH, is to observe the continuity of the outer retina (photoreceptor layer). Iwasaki et al26 analyzed the influence of the ILM inverted flap technique on the structures of the outer retinal layer by comparing 14 cases operated with the use of this technique to 10 cases operated with the conventional technique. The rates of postoperative recovery of the outer limiting membrane and of the ellipsoid zone in the inveted group were lower (21.4 vs. 70.0%), as also was the improvement of VA (9.0 vs. 22.5%).

Park et al27, in a study comparing the inverted flap technique and the technique of IML insertion into the MH, showed superiority of the former technique, also used in the present study, with complete resolution of the defects of the ellipsoid zone and of the outer limiting membrane being observed in 7 and 8 eyes, respectively, in the inverted flap group. In contrast, full resolution was not observed in any of the eyes of the insertion group. Mean final VA was also better in the inverted flap group.

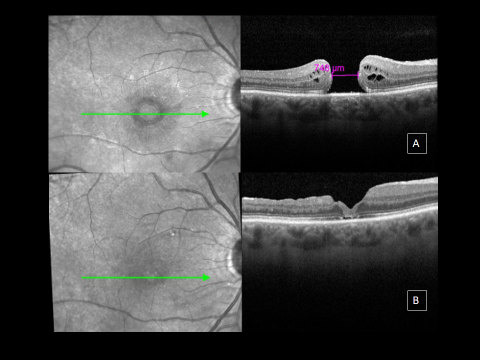
In addition to this described technique, the options reported in the literature for large macular holes, amniotic membrane tamponade40, autologous ILM transplant29,30 or neurosensory retinal free flap transplant31. The use of adjuvants such as autologous serum32-34, whole blood serum35, platelet concentrate36,37, thrombin38 and tumor growth factor beta (TGF-β2)39 has also been reported. One of the great advantages of the present technique is the use of a tissue already present in the retina, with no need of blood processing and no need for havestin tissue from other retinal regions. In addition, the advantage of the pedicule flap is that it won’t move from the edge of the macular hole during fluid air-exchange, allowing easier positioning of the ILM tissue into the hole, when compared to other free flaps techniques.

On the other hand, this technique can’t be employed for persistent holes, where the ILM has already been peeled around the fovea. For this reason, our group has worked on mathematical models to predict macular closure rates using OCT parameters (Pinto et al. 2020) and use the ILM pedicle technique on the firt approach for large macular holes hic have OCT parameters related to macular closure rates lower than 80%.

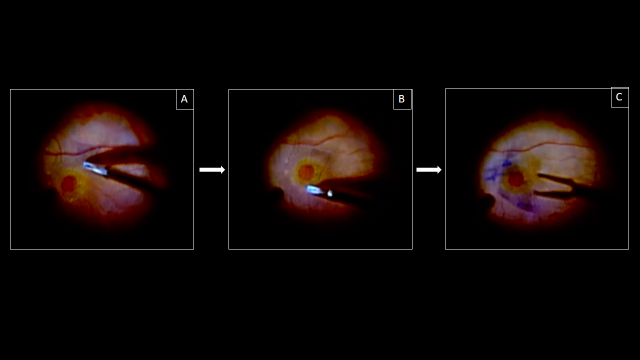
The present study describes the first brazilian case series of large MH treated by the inverted pedicle IML flap technique. In large holes (>700 μm), this technique showed prelimiary promising results and further studies are warranted..

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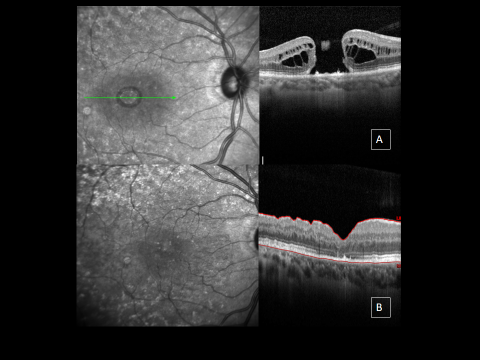
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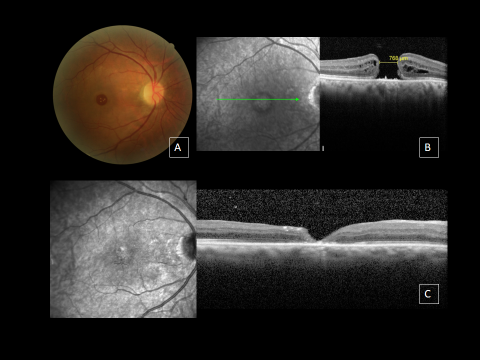
**FIGURE 1 :** Optical coherence tomography of the right eye before surgery, showing Full thickness macular hole **(A)**. Five months after surgery, with Macular hole closed **(B)**. Note the reorganization of the photoreceptor layer of the retina



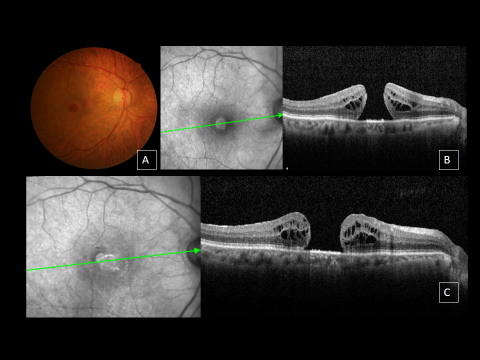
**FIGURE 2** : Pedicle internal limiting membrane flap technique **(A-B-C)** **A:** ILM peeling starts inferiorly to the macular hole (surgeon view); **B:** the ILM is carefully dissected around the macular hole; **C**: The ILM flap remains attached to the temporal macular hole edge and is trimmed with the vitrectomy probe using the scissors mode.



**FIGURE 3 :**Optical coherence tomography of the right eye before surgery, showing Full thickness macular hole with intraretinal cysts **(A)**. Six months after surgery, with Macular hole closed **(B)**.



**FIGURE 4 :**Color retinography and optical coherence tomography (OCT) of the right eye before surgery, showing large macular hole **(A-B)**. Five months after surgery, with macular hole closed **(C)**.



**FIGURE 5 :**Color retinography and optical coherence tomography (OCT) before surgery, showing large macular hole **(A-B)**. Six months after surgery, MH with dimensions similar to baseline values **(C)**.