Idiopathic Macular Hole Surgery without Intraocular Gas Tamponade: Surgical Technique, Biological Rationale, and Initial Clinical Experience

Hejsek Libor [1,2]

[2]Department of Ophthalmology, University Hospital Hradec Králové, Czech Republic
[2]Department of Ophthalmology, Faculty of Medicine in Hradec Králové, Charles University, Czech Republic



Doc. MUDr. Libor Hejsek, Ph.D., FEBO

Correspondence address:
Oční klinika
Fakultní nemocnice Hradec Králové
Sokolská 581
500 05 Hradec Králové
Czech Republic
E-mail.: libor.hejsek@fnhk.cz

Submitted to the editorial board: July 1, 2026
Accepted for publication: July 25, 2026
Available on-line: October 13, 2026
http://doi.org/10.31348/2026/35

The author declares no conflict of interest. This study received no financial or commercial support from any pharmaceutical or medical device company.
I further solemnly declare that this study has not been submitted to any other journal or printed elsewhere.

SUMMARY

Aim: The aim of the study is to describe the technique of idiopathic macular hole (IMH) surgery without the use of intraocular gas tamponade and to present the author's first clinical experience.
Material and Methods: The operation is performed using pars plana vitrectomy, with the creation of an inverted internal limiting membrane flap (ILM flap). The flap of the patch is temporarily stabilized with decalin and then with an ocular viscoelastic device, without the subsequent use of gas tamponade (and without face-down positioning). The anatomical and functional outcome was evaluated with the aid of optical coherence tomography (OCT) and best-corrected visual acuity. Two case reports of patients with successful IMH closure using this technique are presented.
Results: In all presented cases, anatomical closure of the macular hole was achieved and visual acuity improved. OCT demonstrated a relatively rapid restoration of the foveal architecture. The postoperative course was without complications and the patients were not burdened by the limitations and risks associated with gas tamponade.
Conclusion: IMH surgery without gas tamponade represents a promising alternative to standard surgery. With the correct ILM flap technique, it enables us to achieve comparable anatomical and functional results while reducing the burden on the patient. However, further prospective studies are necessary to confirm the effectiveness of this method.
Key words: idiopathic macular hole, pars plana vitrectomy, peeling, ILM flap, gasless surgery

Čes. a slov. Oftal., 82, 2026, No. x, p.

INTRODUCTION

Idiopathic macular hole (IMH) is a full-thickness foveal defect of the neuroretina in the region of the fovea, leading to a pronounced deterioration of central visual acuity (VA) and disturbing metamorphopsias. At present the standard treatment is pars plana vitrectomy (PPV) with peeling of the internal limiting membrane (ILM) performed using a variety of procedures, and subsequent intraocular gas tamponade, frequently combined with postoperative positioning for several days.

Despite the high success rate of macular hole (MH) closure (more than 90%), the use of gas tamponade is associated with a considerable burden on the patient, including transitory functional "blindness" in the operated eye (gas tamponade markedly limits visual functions), restriction of regular activities, the need for postoperative positioning, the risk of increased intraocular pressure or accelerating the development of cataract [1–3].

Although intraocular gas tamponade has been considered a standard component of the surgical treatment of IMH for more than three decades, its actual benefit in the period following the creation of the technically inverted ILM flap remains the subject of debate. Current experimental and clinical studies suggest that the dominant role in MH healing may in fact be played by biological repair mediated by Müller cells and the creation of a mechanical barrier against the flow of intraocular fluid, rather than by the actual effect of long-term intraocular tamponade.

Recently a number of studies have been published describing the possibility of IMH closure without the use of gas tamponade. These procedures are based on modification of the technique of the ILM flap, which is used as a biological scaffold of the MH, often stabilized with viscoelastic material, autologous blood or other materials (e.g. human

amniotic membrane gel). Case reports currently being published present a very high percentage of anatomical closure, comparable with conventional procedures [1,4].

The aim of this study is to describe the technique of IMH surgery without the use of intraocular gas tamponade, and to present the author's first experiences with this technique.

MATERIAL AND METHOD

The operation is performed using a standard three-port procedure (usually 25G or 27G system), ideally under local anesthesia (Unity VCS /Vitrectomy Cataract System/, Alcon).

Used surgical procedure:

1. Routine PPV: removal of retrolental vitreous, performance of central and partially peripheral vitrectomy, induction of the posterior vitreous membrane detachment (unless spontaneously detached already before surgery).
2. Staining of the posterior pole with membrane blue, when the inner ILM is better visible.
3. This is followed by the creation of a pedunculated (hinged) flap in the superior temporal quadrant of the macula. The flap is not detached from the periphery of the IMH. The flap is then folded (Figure 1) over the MH (inverted flap) and temporarily attached to the surface of the retina (temporarily fixed) with a small decalin bubble (Figure 2). The ILM flap is prepared in the superior temporal quadrant of the macula in such a manner that after it has been folded over the defect, the maintenance of its position in the early postoperative period is facilitated by gravitational force, while simultaneously ensuring the protection of the maculopapillary bundle.
4. Decalin is temporarily retained in the macula, while PPV continues (trimming and checking of the periphery and vitreous base).
5. At the end of the operation, disperse viscoelastic material is applied instead of decalin (Figure 3), and the vitreous cavity is left filled only with the surgical solution from infusion and a compound of viscoelastic material in the macular region.

Postoperative regimen

At the end of the operation the patient is transported from the operating theater in a supine position, and remains in this position for 60 minutes without the need for subsequent posturing. A regimen of only rest is recommended. Local postoperative therapy is standard (topical antibiotics with corticoids).

The principle of this technique is to achieve mechanical and biological closure of MH with the aid of the ILM flap alone, which prevents the infiltration of fluid through the defect, and at the same time serves as a pathway for glial repair mechanisms [1].

In the following two case reports, values of VA were measured on a Snellen chart and OCT was performed using the instrument Heidelberg Spectralis (Germany). Intraocular pressure was measured using non-contact tonometry (NIDEK, Japan). The patients were examined before surgery, one week after the procedure, and subsequently one and two months after PPV.

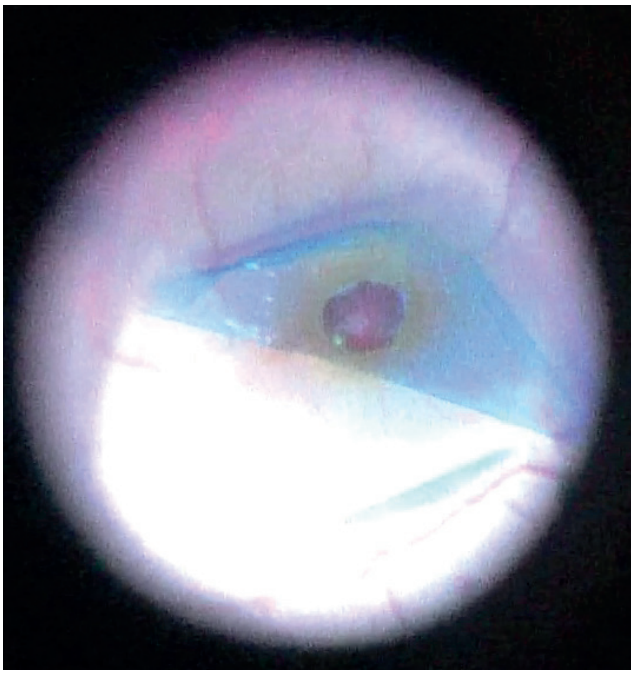


Figure 1. Folded ILM flap in the upper outer quadrant (view from the operating microscope)

ILM – internal limiting membrane

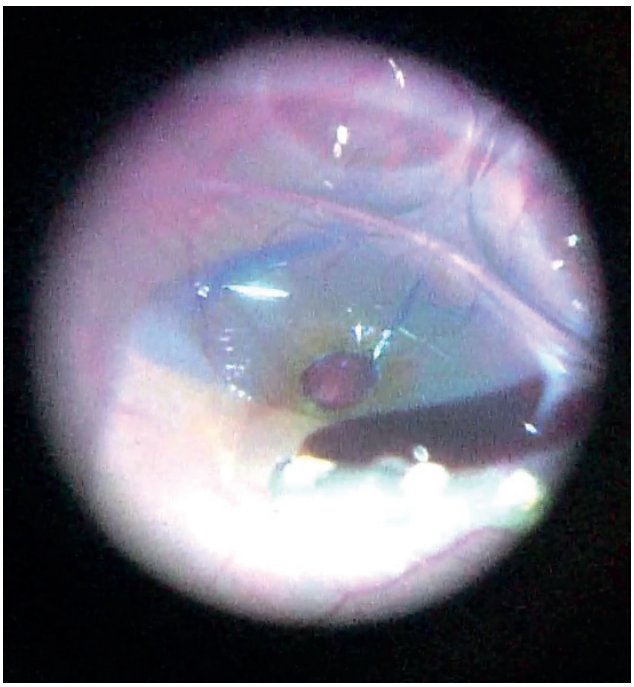


Figure 2. The folded ILM flap is covered with a decalin bubble (view from the operating microscope)

ILM – internal limiting membrane

Case report 1 (IMH, high myopia, monocular vision)

The patient was a woman with complete IMH (stage 2 according to the Gass classification) in the only remai-

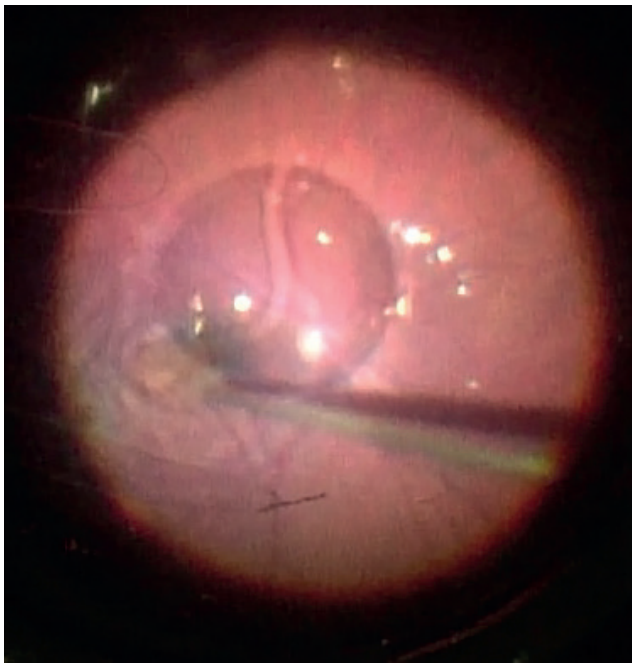


Figure 3. Viscomaterial is applied to the edge of the decalin bubble

ning functional left eye, year of birth 1956.

Ocular history: high myopia (approx. 13.0 diopters), in the patient's youth vision was the same in both eyes. In 1997 and later PPV was repeatedly performed due to retinal detachment and re-detachment in the right eye, which over the course of time developed secondary glaucoma, keratopathy and blindness. In 1998 the patient underwent cerclage in the left eye for rhegmatogenous retinal detachment. In 2022 the patient underwent cataract surgery on the left eye. All the procedures were performed at another center.

Subjectively: deterioration of vision in the left eye approximately from the beginning of 2026, vision blurred and distorted. The right eye has been "weak" for several years, totally blind for approximately 2–3 years, the patient occasionally feels pain in the eye and uses Azopt (brinzolamidum10 mg/ml) eye drops 2x daily. The patient wears reading glasses.

Current finding in right eye (RE): visual acuity on the level of incorrect light projection, the eye is quiet, cornea with diffuse keratopathy, microbullae, in the center incipient zonular keratopathy, diffuse punctate fluorescein staining, anterior chamber clear, of adequate depth, normal iris, iridodonesis, pupil rounded, relaxed, aphakia, no further findings. Intraocular pressure is palpably normal.

Preoperative finding in left eye (LE): natural visual acuity 5/20, with correction -1.25 /-2.50 cyl ax 130° = 0.4. Intraocular pressure (IOP) is 19 torr. The eye is quiet, cornea transparent, shiny, anterior chamber clear, of adequate depth, iris is normal, pupil rounded, relaxed, in artificial mydriasis: posterior chamber intraocular lens (PCIOL) in situ, window in posterior capsule following laser capsulotomy. Finding on fundus and artificial mydriasis: vitreous fibrillated with opacities, optic disc with sharp margin, on normal level, pink, myopic cone, C/D ratio 0.6, peripapillary thinned atrophic retina, IMH in macula, diffuse retinal thinning, traces of cryocoagulation, paving-stone degeneration, cerclage ridge circular, retina attached throughout periphery.

OCT of macula of LE (Figure 4): fine epimacular membrane, attached vitreous, cystically altered edges, complete IMH, atrophic choroid to myopia.

The procedure on the sole functioning eye took place without any complications, according to the above-described method. The next day the patient felt well upon discharge, vision was unchanged. The objective finding is as follows: VA s -1.25sf (stenopeic) 0.4. IOP in LE 16 torr.

LE: conjunctiva only slightly irritated postoperatively, postoperative wounds holding, cornea transparent, anterior chamber clear, iris is normal, pupil in artificial mydriasis, PCIOL centered, fenestration of posterior capsule. On the fundus the vitreous cavity is clear, papilla has large myopic cone, C/D ratio 0.6. Retina myopically thinned to atrophic, macular hole closing – not visible on ophthalmoscopy, atrophic changes of the retina on the periphery, traces of previous laser and cryocoagulation, cerclage ridge circular. OCT of macula of LE (Figure 5): incipient IMH closure.

At the follow-up examinations the patient was subjectively satisfied, stated a gradual improvement of vision and reduction of metamorphopsias. VA adjusted to the value of 0.5 (with own correction), IMH not visible on the fundus and the finding on OCT also markedly improved (Figure 6).

Case report 2 (post-traumatic IMH in childhood)

This is a case of IMH in childhood, in which the onset of MH is associated with a blunt trauma (contusion resulting from a water jet) in the past. The patient is an 11-year-old girl with moderate myopia.

In the ocular history is bilateral moderate myopia, vision was always the same in both eyes, with the refractive

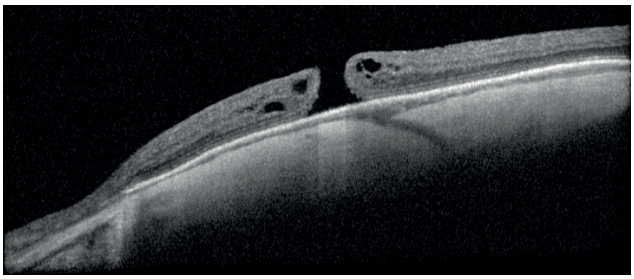


Figure 4. Complete MH on a myopic background

MH – macular hole

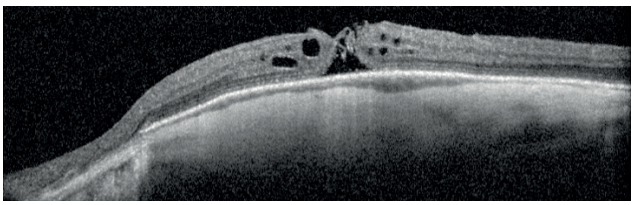


Figure 5. Closing macular hole

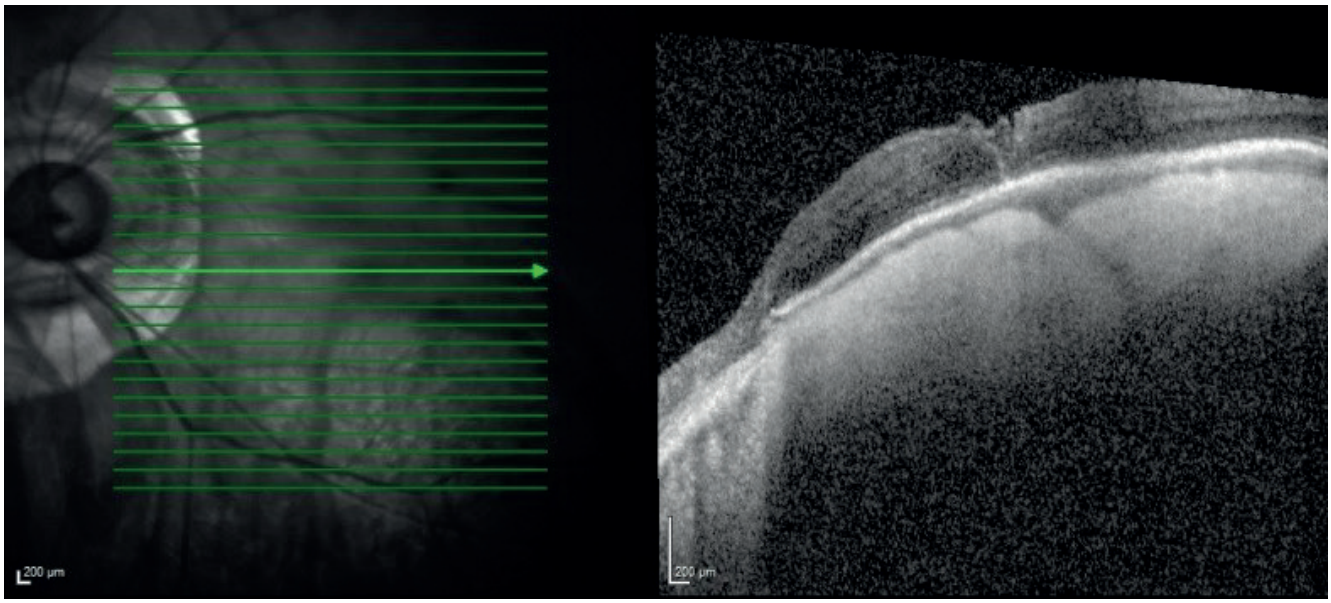


Figure 6. Closed macular hole two months after surgery without gas tamponade

error corrected by glasses since pre-school age. In the summer of 2025, the patient was hit in her left eye with a jet of water from a sprinkler on a football field. She did not seek an ophthalmological examination. In 2026 IMH was determined at a preventive check, initially a conservative procedure was applied with waiting for the possibility of spontaneous closure. The patient subjectively stated that she perceived a defect of central vision in the visual field of the left eye, in which the image was disruptively distorted.

Current finding in right eye (RE): VA 1.0 (with correction -2.75 / -3.0 cyl ax 9°). The right eye had a physiological finding on the anterior and posterior segment, IOP in the RE 16 torr.



Figure 7. Intraoperative image of the foveal finding before peeling

Preoperative finding in left eye (LE): with correction -2.0 / -3.0 cyl ax 7°, VA 0.25, and IOP 16 torr. LE is quiet, with a normal finding on the anterior segment, lens clear. On the fundus the vitreous was clear, optic disc with sharp margin, on normal level, without pathological excavation, central retina with MH of an older date, irregularities of the pigment epithelium visible in the depth of the hole (Figure 7), in the extreme lower periphery pigmentation (post-contusion changes), retina attached, retinal tear is found. OCT of the macula of the LE (Figure 8) showed complete MH throughout the entire thickness and abnormalities of the retinal pigment epithelium (RPE).

The operating procedure was not entirely standard due to the firmly attached posterior vitreous membrane, especially in the place of post-contusion changes. Preventive laser photocoagulation was added in the periphery, otherwise everything took place without complications, according to the above-described method.

On the first day after surgery the patient was satisfied, without any major complaints, VA with own correction unchanged (0.25), IOP in LE 6 torr. The eye showed signs of commensurate postoperative irritation, cornea trans-

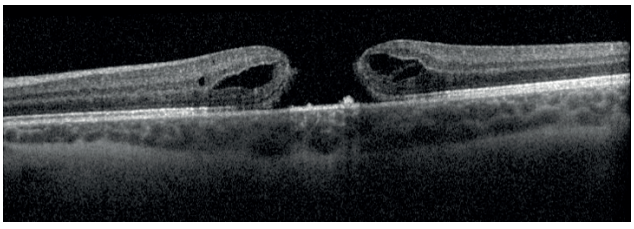


Figure 8. Complete MH, chronic changes (probably also post-contusion) of the RPE line in the fovea

MH – macular hole, RPE – retina pigment epithelium

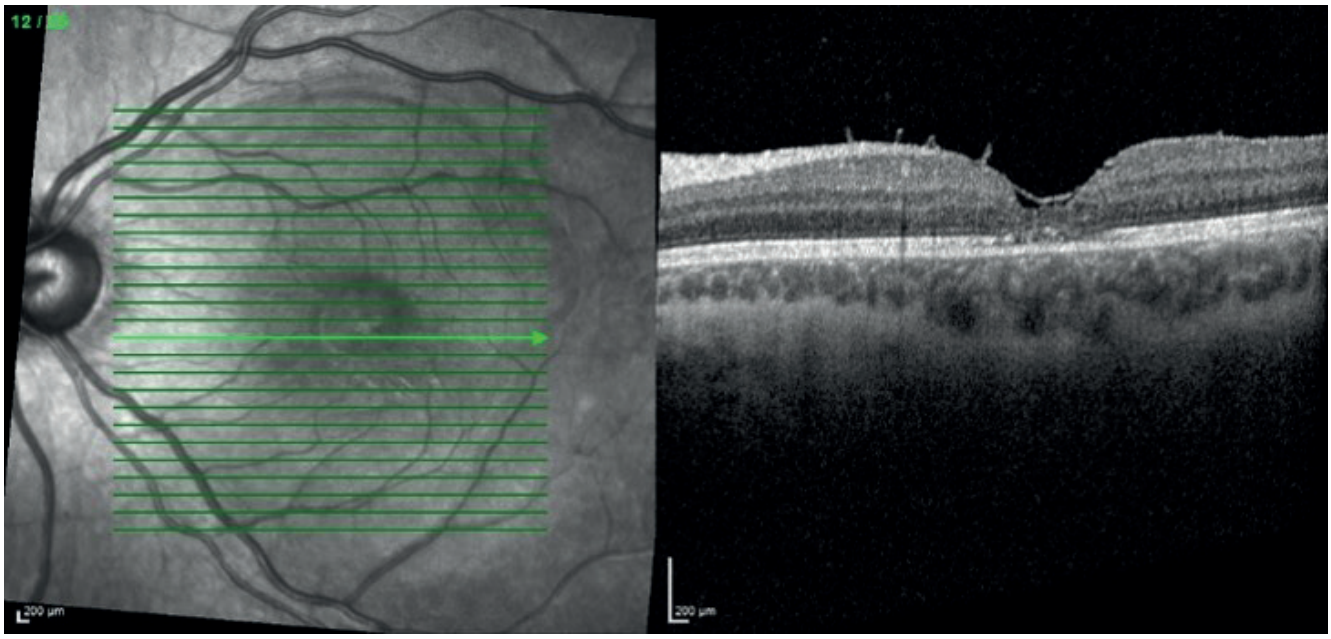


Figure 9. Complete closure of the MH, the lines of the outer layers of the neuroretinal are restored
MH – macular hole



Figure 10. Comparison of postoperative and preoperative OCT findings 2 months after PPV without gas tamponade
PPV – pars plana vitrectomy

parent, anterior chamber clear, iris is normal, pupil in artificial mydriasis, lens clear. On the fundus of the LE the papilla was normal, macula with foveal reflex, MH healed, retina attached throughout its entire scope, traces of laser forming on the periphery.

One week after surgery the patient remained satisfied, without complaints, and stated a subsidence of metamorphopsias. VA improved to 0.4 (with own correction) and IOP was normal. The operated eye was quiet, cornea transparent, anterior chamber clear, iris is normal, pupil in artificial mydriasis, lens clear. On the fundus the papilla was normal, macula with foveal reflex, IMH not visible, depigmentation of the RPE remained visible in the depth, retina attached throughout its entire scope, traces of laser treatment in the periphery.

On OCT we could see a relatively rapid adjustment of the anatomical proportions in the center (Figure 9).

At further follow-up examinations the patient remained subjectively satisfied, stating a gradual improvement of vision and disappearance of metamorphopsias. VA adjusted to 0.5 (with own correction), IMD not visible on the fundus. On OCT irregularities remained in the outer layers of the neuroretina and RPE (Figure 10).

DISCUSSION

The traditional concept of MH surgery assigns a key role to gas tamponade, which mechanically "presses" the edges of the defect together and thereby limits the infiltration of fluid into the hole [5,6]. The success rate of surgery has been markedly increased by versions using a flap in ILM peeling, confirming the fundamental significance of tamponade. However, more recent studies indicate that an essential factor may rather be elimination of the flow of fluid through the defect and the creation of a substrate for cell proliferation [1–3].

The ILM flap functions here as a biological scaffold, supporting the migration of Müller cells and repair of the neuroretina, in which its stabilization over the surface of the IMH may be secured even without the use of gas. Current observations indicate that an ILM flap acts not only as a mechanical patch over the MH. The ILM creates a substrate enabling the migration and proliferation of Müller cells, which share in the reconstruction of the foveal architecture. Histological and OCT studies have demonstrated a progressive reorganization of the outer layers of the retina following successful closure of macular hole, in which restoration of the external limiting membrane precedes the restoration of the ellipsoid zone of the photoreceptors.

Advantages of IMH surgical technique without gas tamponade

The main advantages include: preservation of immediate at least original functional vision after surgery, no need for postoperative positioning (older patients, children, obese, orthopedic patients etc.), no limitations in connection with the presence of gas (e.g. air travel), lower risk of IOP elevation in the postoperative period, lower risk of developing complicated cataract. These factors may markedly improve patient comfort and reduce the time required for convalescence.

The series of operations without tamponade published to date show a very high percentage of MH closure (approx. 92–100%), which is comparable with standard surgery using gas tamponade [1,4]. In a comparative study conducted by Szeto et al., anatomical closure was achieved in 95.2% of eyes operated on without gas tamponade in comparison with 94.1% operated on using the standard technique. No difference in final VA was determined between the groups, while early postoperative vision was superior in the group without gas tamponade.

An interesting observation is the potentially low level of foveal gliosis and more rapid restoration of the foveal architecture, which may also lead to better functional results in the early postoperative period [7,8].

The limitations and relative disadvantages of this technique include the technical complexity of the procedure (genuinely precise preparation of the ILM flap and subsequent detailed work with it), the high dependency on the stability of the ILM flap, the absence of a "safety reserve" in the form of gas tamponade (both with regard to IMH closure and with regard to the risk of postoperative retinal detachment), and the thus far limited body of evidence, which is predominantly based on smaller series of cases.

The risks of this technique include the possibility of dislocation of the flap in the early postoperative period, failure of MH closure and the need for reoperation with the use of gas tamponade. The success of this technique also has not been verified in the case of larger or long-term macular holes, in which this technique may be less reliable, as a consequence of which it is appropriate to consider indication for this type of procedure very carefully and individually.

Ongoing randomized trials (e.g. the GEM trial) aim to confirm the safety and efficacy of the "gas-free" technique in comparison with the standard procedure [1].

If non-inferiority is confirmed, surgery without gas tamponade may come to represent a significant alternative or new standard, at least for selected patients.

REFERENCES

1. Murphy GSP, Wafa HA, Tarpey M. Gas versus Gasless surgery for full thickness macular hole (GEM): study protocol for a randomized feasibility trial. BMJ Open Ophthalmology. 2025 Dec 25;10(1):e002260. doi: 10.1136/bmjophth-2025-002260
2. Michalewska Z, Michalewski J, Adelman RA, Nawrocki J. Inverted internal limiting membrane flap technique for large macular holes. Ophthalmology. 2010;117(10):2018-2025.
3. Shroff D, Gupta P, Atri N. Inverted internal limiting membrane flap technique for macular hole closure: patient selection and special considerations. Clin Ophthalmol. 2019;13:671-678.
4. Casini G, Mura M, Figus M. Inverted internal limiting membrane flap technique for macular hole surgery without extra manipulation of the flap. Retina. 2017;37(11):2138-2144.

5. Kelly NE, Wendel RT. Vitreous surgery for idiopathic macular holes. Results of a pilot study. Arch Ophthalmol. 1991;109(5):654-659.
6. Steel DH, Lotery AJ. Idiopathic vitreomacular traction and macular hole: a comprehensive review. Eye. 2013;27(1):1-21.
7. Szeto SKH, Lam JTW, Yu AHY. Macular hole closure by internal limiting membrane flap without gas tamponade versus conventional surgery: a comparative study. Ophthalmology. Retina. 2025;9(11):1034-1043. doi:10.1016/j.oret.2025.06.005
8. Grant S, Adrean SD. Surgical macular hole closure without a gas tamponade. J Vitreoretin Dis. 2021;6(1):14-21.