OUTCOMES OF 25-GAUGE PARS PLANA VITRECTOMY IN THE TREATMENT OF IDIOPATHIC MACULAR HOLE

Takáčová Adriana [1], Kéri Petra [1], Krišková Petra [1], Majtánová Nora [1,2], Kolář Petr[1,2]

[1]Department of Ophthalmology of Slovak Medical University and University Hospital Bratislava, Slovakia
[2]Faculty of Medicine, Slovak Medical University, Bratislava, Slovakia

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Primary author
MUDr. Adriana Takáčová

Corresponding author
Prim. MUDr. Nora Majtánová, PhD.
Očná klinika SZU a UNB
Antolská 11
851 07 Bratislava
E-mail: nora.majtanova@gmail.com

SUMMARY

Aim: The main aim of this study is to evaluate the anatomical and functional results of pars plana vitrectomy (PPV) with peeling of the internal limiting membrane (ILM), membrane blue staining and subsequent expansile gas tamponade (perfluoropropane) in the treatment of idiopathic macular hole (IMH).

Material and methods: The retrospective analysis consisted of 100 eyes of a total of 100 patients (61 women and 39 men) with IMH, operated on at the Department of Ophthalmology of the Slovak Medical University and University Hospital Bratislava from 1 January 2021 to 1 January 2024, using 25-gauge PPV with ILM peeling and perfluoropropane tamponade (C3F8) of 15% concentration. After surgery, the patients were required to remain in a face-down position for at least one week. Best corrected visual acuity (BCVA), minimal linear diameter (MLD) on optic coherence tomography, macular hole closure type and occurrence of complications were evaluated. The obtained results were expressed with the use of arithmetic averages and displayed in graphs.

Results: Primary closure of macular hole was achieved in 93 patients (93%). The most frequently occurring type of closure was 1A. After surgery, the BCVA of all patients improved, from an average value of 0.101 preoperatively to 0.300 one year after surgery. In all groups of patients (regardless of the size of the macular hole before surgery), during the one-year follow-up period there was a gradual increase in BCVA with its stabilization by 6 months. The main factors that influenced postoperative BCVA were the preoperative values of MLD and BCVA.

Conclusion: PPV with ILM peeling and perfluoropropane tamponade is an effective treatment for idiopathic macular holes with a success rate of more than 90%. This surgical procedure, associated with a relatively low number of complications, brings patients a definite improvement of BCVA.

Key words: macular hole, pars plana vitrectomy, ILM peeling, perfluoropropane

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INTRODUCTION

Macular hole (MH) represents a defect in the center of the fovea, throughout its entire thickness from the internal limiting membrane (ILM) to the outer segments of the photoreceptors. The prevalence of idiopathic macular hole (IMH) reaches 0.5% of the population aged over 60 years, in which bilateral occurrence is recorded in 10% of patients [1]. The worldwide incidence is 4 to 8 cases per 100 thousand per annum, making macular hole a significant cause of visual morbidity [2].

Based on observation using optical coherence tomography (OCT), in 2013 the IVTS ("International Vitreomacular Traction Study") classification was introduced, which divides MH according to minimal linear diameter (MLD) into small (≤ 250 µm), medium (250–400 µm) and large (> 400 µm) [3].

In 2023, the "CLOSE" study group created a new classification system, which above all takes into account the surgical results and implements new surgical procedures in the solution of types of MH which until recently were considered inoperable (Table 1). The authors of this study are of the opinion that type L, XL and XXL holes can be treated surgically with the aid of ILM peeling and/or the creation of an ILM flap. Alternative surgical techniques (i.e., perifoveal hydrodissection, amniotic membrane graft and autologous retinal transplant) should be applied exclusively for such MHs which ILM peeling or an ILM flap failed to close, or in the case of an MLD of > 800 µm [4].

Even despite the fact that there are non-surgical modalities for the treatment of MH (for example intravitreal injection of ocriplasmin), pars plana vitrectomy (PPV) remains the gold standard. In 1971 Robert Machemer was the first to carry out an operation on the posterior segment of the eye by means of a closed system using a 17-gauge set of instruments [5], and PPV has since undergone several modifications up to the mini-invasive form in which we know it today [6–8]. At present 25-gauge to 27-gauge PPV is implemented, with ILM peeling, gas tamponade and subsequent postoperative placing of the patient in a face-down position, which is especially important in the case of holes with an MLD of > 400 µm [9].

Table 1. Classification of macular hole according to minimal linear diameter, proposed by „CLOSE" study group in 2023 [4]

Macular hole type	Minimal linear diameter (MLD)
„Small" (S)	≤ 250 µm
„Medium" (M)	> 250 a ≤ 400 µm
„Large" (L)	> 400 a ≤ 550 µm
„X-Large" (XL)	> 550 a ≤ 800 µm
„XX-Large" (XXL)	> 800 a ≤ 1000 µm
„Giant"	> 1000 µm

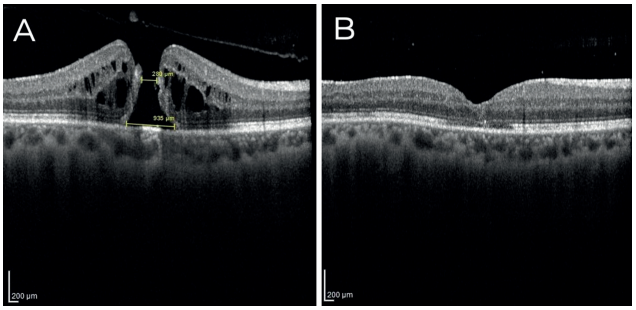


Figure 1. Macula OCT. (A) Full-thickness macular hole with cystoid edges – before surgery. (B) Closed macular hole with foveolar depression – 3 months after pars plana vitrectomy

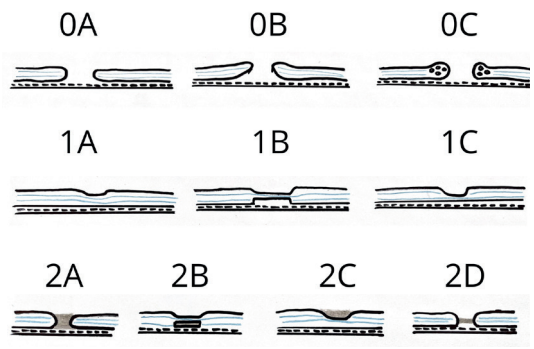


Figure 2. Schematic illustration of macule hole closure types. Blue lines represent inner and outer plexiform layers, and the grey color represents autologous or heterologous filling (for more detailed description see text)

A condition in which closure of the fenestration and the creation of a foveal depression is achieved is considered to constitute successful surgery (Figure 1), as well as a condition in which closure of the hole is not achieved, but its edge is flattened [10].

Depending on the manner of restitution of the retinal layers after surgery, we differentiate between 3 possible types of closure of MH (Figure 2):

- type 0 – MH open (0A: attached edges; 0B: raised edges; 0C: edematous edges),
- type 1 – MH closed (1A: reconstruction of all retinal layers; 1B: breach in outer layers; 1C: breach in internal layers),
- type 2 – MH closed with autologous or heterologous filling tissue (in the case of the use of an ILM flap or the aforementioned alternative surgical techniques), which impairs the normal anatomy of the fovea (2A: filling tissue through all retinal layers; 2B: filling tissue in outer layers and reconstruction of inner retinal layers; 2C: filling tissue in internal layers and reconstruction of outer retinal layers; 2D: filling tissue in letter H shape) [11].

MATERIAL AND METHODS

The retrospective study incorporated 61 women and 39 men (total 100 eyes) with idiopathic MH, aged between 48 and 81 years (mean age 66 years), who were operated on at the Department of Ophthalmology of the Slovak Medical University and University Hospital Bratislava, Slovakia, during the period from January 1, 2021, to January 1, 2024. Before surgery, each patient was examined for intraocular pressure, best corrected central visual acuity (BCVA) on ETDRS charts, and the anterior and posterior segment of the eye on a slit lamp. At the time of indication for surgery, all the patients were pseudophakic. According to MLD measured by caliper for OCT (Heidelberg Engineering, Germany), we divided the patients into 4 groups. Group S (MLD ≤ 250 µm) contained 12 eyes (12%), group M (MLD > 250 and ≤ 400 µm) contained 41 eyes (41%), group L (MLD > 400 and ≤ 550 µm) contained 32 eyes (32%) and group XL (MLD > 550 and ≤ 800 µm) contained 15 eyes (15%) (Graph 1). No macular holes with an MLD of > 800 were present in our cohort during the observation period. Patients who had other retinal pathologies (with the exception of epiretinal membrane), glaucoma, previous vitreoretinal surgery, diabetic retinopathy or high myopia with axial length of the eyeball greater than 27.0 mm in their medical history were excluded from the cohort. Epiretinal membrane was present in 21 patients (21%).

All the patients underwent 25-gauge PPV on a Constellation (Alcon) system under general anesthesia. After the insertion of three trocars across the pars plana region, the posterior vitreous was removed and an examination of the retinal periphery beneath the scleral indentation was performed. After staining with membrane blue, ILM peeling was performed with the aid of "endgripping" for-

ceps (Alcon), as well as any relevant peeling of the epiretinal membrane (if present). The scope of the peeling was approximately 2–4 PD (papilla diameter). This was followed by the use of tamponade with the expansive gas C3F8 (perfluoropropane) in a diluted concentration of 15%. After extraction of the trocars, sclerotomies and the conjunctiva was sutured with the absorbable suture Vicryl 7-0. Patients were recommended to remain in a face-down position for a period of one week, with the greatest emphasis on maintaining this position during the first 24–48 hours after surgery.

The patients were assessed 1, 3, 6 and 12 months after surgery. In all the patients we evaluated best corrected central visual acuity (BCVA) by means of ETDRS charts before surgery (decimal values) and subsequently 1, 3, 6 and 12 months after surgery.

After surgery we assessed postoperative closure of MH, i.e., anatomical reconstruction of the foveal region of the retina, with the aid of OCT, on the basis of which patients were divided into 4 groups according to the type of closure of MH – group 1 (closure type 1A), group 2 (closure type 1B), group 3 (closure type 1C) and group 4 (closure type 0A). With reference to the fact that we did not use an ILM flap or any of the above-mentioned alternative surgical techniques, type 2 closures did not occur in our cohort.

We expressed the numerical values also in percentages, and in expressing the results we used above all an arithmetical average (stating the minimum and maximum values in brackets), as well as display with the aid of synoptic graphs.

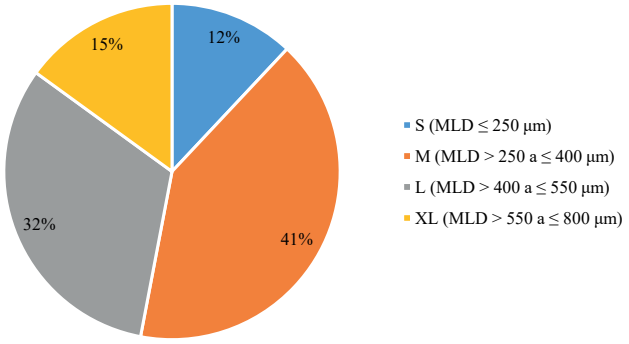
RESULTS

The mean observation period was 8 months (1–24). The mean size of MH preoperatively reached a value of 401.26 µm (188–795).

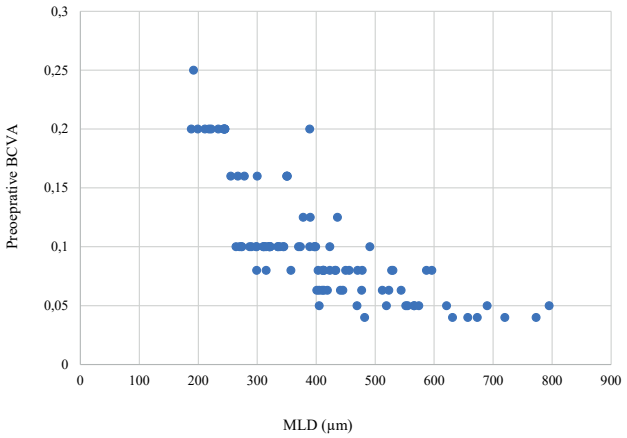
In the observed cohort, the mean preoperative value of BCVA was 0.10 (0.04–0.25). Mean preoperative BCVA was higher in those patients who had a smaller MLD (Graph 2). In the first month after surgery we recorded an improvement of mean BCVA to 0.15 (0.05–0.63), subsequently in the third month to 0.19 (0.06–0.63), in the sixth month to 0.24 (0.08–0.63) and one year after surgery to a mean value of 0.30 (0.08–0.63). One year after surgery, visual acuity remained the same in 3 patients (3%), and in all the other cases an improvement was achieved. In 86% of patients, visual acuity had improved by 3 or more rows on the ETDRS chart one year after surgery. Graph 3 illustrates that after surgery a linear improvement of BCVA was achieved over time in all groups of patients, regardless of the size of the macular hole before surgery.

At the time of 1 month after surgery, we achieved one of the type 1 closures of MH in 93 eyes (93%). Type 1A appeared in as many as 73 eyes (73%), type 1B in 14 eyes (14%) and type 1C in 6 eyes (6%). In 7 patients (7%) MH remained open, but with attached edges of the 0A type; all of these cases concerned macular holes of the XL type. The success rate of closure for S, M and L holes was 100%, and for type XL 46.7%. Upon a comparison of the individual groups of patients based on the type of closure, we observed that the highest values of BCVA were recorded in patients in whom reconstruction of the foveal region was achieved by type 1A closure (Graph 4).

The incidence of complications was relatively low. In 26 patients (26%) we detected retinal tears or degeneration upon an examination of the retinal periphery, which were treated in all cases by means of endolaser coagulation supplemented by circular laser barrage. An increase of intraocular pressure after surgery was recorded in 10 patients (10%) and managed by means of administering local antiglaucoma therapy. In 7 patients (7%), dispersion of erythrocytes into the vitreous cavity developed shortly after the operation, with spontaneous regression within a maximum of 3 days after surgery. None of the stated complications that occurred in our cohort were serious, and all were well managed.



Graph 1. Preoperative population of the patients with macular hole according to minimum linear diameter (MLD) measured with a caliper on OCT



Graph 2. Scatter plot showing the correlation between macular hole size and BCVA value before surgery
MLD – minimum linear diameter (µm,) BCVA – best corrected visual acuity

DISCUSSION

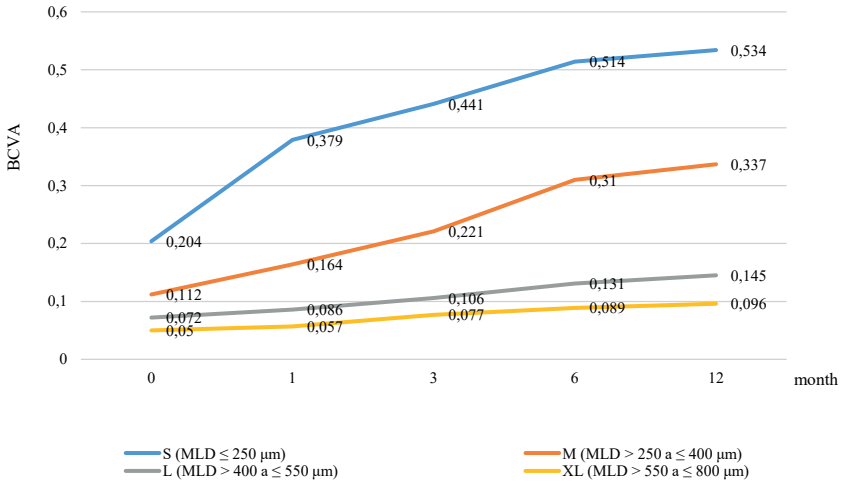
In 2006, Kolář and Vlková published a cohort of 28 patients who had undergone PPV with ILM peeling and gas tamponade for IMH. In this study they achieved complete closure of IMH in 87% of patients, with an improvement of BCVA by more than 1 row on the ETDRS chart in 77%, while all patients were cured of disruptive metamorphopsias of the ILM [14].

In 2011, Hejsek et al. presented the anatomical and functional results of macular hole surgery with the use of 20-gauge PPV with ILM peeling. In a cohort of 32 patients they recorded primary closure of IMH in 90% of eyes, and in three cases the IMH was not closed. Baseline BCVA was within the range of 0.1 to 0.5, and after one year of observation this had improved by 2 or more rows in 84% of eyes., by 3 or more rows in 56% of eyes and by 4 or more rows in 16% of eyes [15].

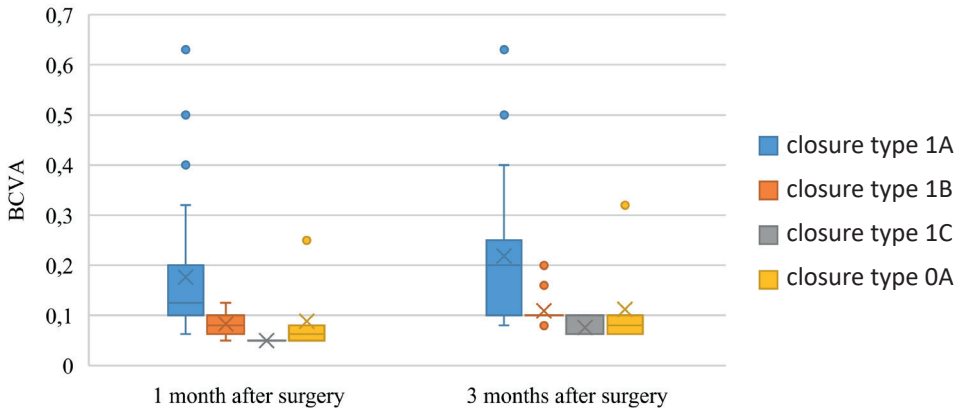
These findings demonstrate that improvements in the diagnosis and surgical technique have also brought about an increase in the success rate of PPV. However, it is not possible to compare the above results reliably with our own cohort, with reference to the fact that we used the method of 25-gauge PPV.

Comparable data are presented in a retrospective analysis conducted by Veith et al. in 2015, which included 53 eyes following 25-gauge PPV with ILM peeling and gas tamponade for IMH. Anatomical success was achieved in 92.5% and BCVA improved in 94.3% of patients, 79.2% of whom attained improvement by 3 or more rows on the ETDRS chart [16], which correlates with the results in our own cohort. However, it is essential to emphasize that this concerns a cohort of patients smaller than our own by almost one half, and that with the development of vitreoretinal surgery the anatomical and functional success rate of the operation has increased further.

Data from the "CLOSE" study group presents a practically 100% success rate of PPV with the use of ILM peeling and/or the creation of an ILM flap in the case of type S and M macular holes, while in the case of type L holes the success rate is reduced to 97%, for type XL holes 86% and for type XXL holes to 80% [4]. In our co-



Graph 3. Line graph showing the average BCVA before surgery and its gradually increasing improvement at 1, 3, 6, 12 months after surgery
BCVA – best corrected visual acuity



Graph 4. Box plot showing the value of BCVA at 1 month and 3 months per macular hole closure pattern type
MLD – minimum linear diameter (µm), BCVA – best corrected visual acuity

hort the total success rate of primary closure of macular hole was 93%, in which in the case of holes with preoperative MLD of ≤ 550 we achieved a 100% success rate. The results of our observation are therefore comparable with the latest foreign sources.

In our cohort the success rate for type XL holes was only 46.7%, which raises the question as to whether it would be more advantageous to choose the technique of an ILM flap as the method of first choice for such holes. Although the authors of the "CLOSE" study group in 2023 demonstrated that there is a higher success rate of closure upon the use of a flap from the ILM for holes of types L, XL and XXL, the gains of BCVA are lower in comparison with gains of BCVA upon the use of ILM peeling only [4, 11]. The lower gains of BCVA are probably due to the fact that manipulation of the flap from the ILM presents a higher risk of mechanical damage to the RPE, while the flap itself may lead to an excessive glial reaction and hyperproliferation of the Müller cells, which subsequently prevents the adequate reconstruction of the outer layers of the retina [17]. In 2020, Rossi et al. described how reconstruction of the outer layers brings about higher values of BCVA after surgery in comparison with patients with reconstruction of the inner retinal layers [11]. With reference to these observations, we decided to use PPV with ILM peeling as the primary method for all types of macular hole. The objective of our observation was to evaluate the results of patients following PPV with ILM peeling, and for this reason it is beyond the scope of our study to evaluate the individual surgical methods, their results, gains of visual acuity and/or to conduct a mutual comparison thereof. However, in future further studies shall indisputably be necessary in order to compare the surgical methods, which shall help operating surgeons choose the most appropriate method, above all with regard to attaining the best possible restoration of the fovea, and thereby the highest possible gain of visual acuity after surgery.

At present PPV with ILM peeling is a minimally invasive procedure which allows for convalescence and the restoration of visual functions within a relatively short time after the operation. In our observation we described how BCVA demonstrated a linear improvement during the first 12 months after surgery, in which this increase was independent of the preoperative size of MH. This finding can be explained by the fact that the reconstruction of the foveal layers and the restoration of continuity of the ellipsoid zone takes place progressively and slowly [12]. Stabilization of visual acuity mostly takes place approximately 6 months after surgery [13], which is also in congruence with our observations.

Several prognostic factors are described in the literature, which influence resulting visual acuity after macular hole surgery [1]. Above all, the statistically significant factors are preoperative BCVA and size of macular hole [13]. In 2009, Kaňovský et al. analyzed prognostic factors in 91 patients who had undergone PPV with ILM peeling for IMH, in which they demonstrated a statistically significant relationship between the duration of the symptoms and resulting postoperative visual acuity. In patients with a shorter anamnesis we can therefore expect a more pronounced improvement in visual acuity after surgery [18]. Even despite the fact that in our cohort we did not evaluate the length of the anamnesis, our results confirmed that patients with better preoperative visual acuity and smaller MLD attained higher gains of BCVA after surgery.

The aforementioned alternative surgical techniques have also provided us with new ways of anatomical reconstruction of the foveal region, which has necessitated a reclassification of the types of closure of macular hole. The results of the study conducted by Rossi et al. demonstrated that BCVA after surgery is in correlation with the manner of closure, in which better results are attained by patients with type 1 or type 2 closures [11]. These findings also correspond with our observations in the case of our own patients.

CONCLUSION

We can state that after the performance of PPV, primary closure of macular hole was achieved in 93% of patients, whom we thus consider to be cured. A large proportion of these patients experienced a relatively rapid restoration of visual functions and a disappearance of unpleasant metamorphopsias. It is important to consider the fact that surgical targets change, and that the closure of macular hole is not the sole objective of macular hole surgery. At present the restoration of the integrity of the outer layers of the fovea, i.e., the outer limiting membrane and the ellipsoid zone, is coming to the forefront. PPV is a surgical technique that has been proven over the course of many years, which has undergone several modifications up to today's 25-gauge to 27-gauge forms. Our results have demonstrated that 25-gauge PPV with ILM peeling and gas tamponade is an effective treatment for idiopathic MH, with a success rate of over 90%. At present this now constitutes a routine operation, which brings benefits for patients with macular holes of various sizes.

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