Title
PARS PLANA VITRECTOMY FOR THE TREATMENT OF TRACTIONAL AND DEGENERATIVE LAMELLAR MACULAR HOLES

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Pars Plana Vitrectomy for the treatment of tractional and degenerative lamellar macular holes: functional and anatomical results.

Short title: Surgery for lamellar macular holes.

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The authors declare no conflicts of interest

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Abstract:

Purpose: To describe the functional and anatomical outcomes of pars plana vitrectomy (PPV) with peeling of premacular membrane (PMM) or lamellar macular hole associated epiretinal proliferation (LHEP) in eyes with tractional and degenerative lamellar macular holes (LMH).

Methods: In this multicenter, interventional and retrospective study, patients diagnosed with tractional and degenerative LMH treated with PPV, PMM or LHEP peeling and a minimum follow up of 6 months were enrolled. Spectral-domain optical coherence tomography images (SD-OCT) were reviewed. The association of SD-OCT parameters with preoperative and postoperative best corrected visual acuity (BCVA) was analyzed.

Results: One hundred and three eyes with LMH were included, of which 77 (74.8%) were tractional, and 26 (25.2%) were degenerative. Preoperative BCVA was better in the tractional (0.39 ± 0.2 LogMAR) than the degenerative subgroup (0.56 ± 0.2 LogMAR; $p<0.001$). Outer retinal disruption was present in 13 out of 26 eyes (50%) with degenerative LMH but only 11 out of 77 eyes (14.3%) with tractional LMH ($p<0.001$), probably accounting for the differences in BCVA. PMM was found in all tractional LMH eyes, while LHEP was present in all degenerative LMH eyes, with only one case containing both. Mean follow up after surgery was 30.8 ± 28.8 months. Primary anatomical success was achieved in 97 out of 103 eyes (94.2%). Postoperative healing patterns differed significantly between the two LMH subtypes: anatomic foveal restoration occurred earlier in the degenerative subgroup. Postoperatively, BCVA improved in both tractional and degenerative LMH ($p<0.001$

and p=0.012, respectively), but BCVA differences between the two LMH subgroups remained significant with better BCVA in the tractional subgroup (p=0.001).

Conclusions: The presence of PMM in all tractional but no degenerative LMH eyes provides further distinction between these two subtypes. BCVA improved significantly in both subtype of LMH, although functional improvement was larger in the tractional LMH. A complete postoperative anatomical restoration of the foveal microanatomy was rare in the degenerative subtype, reflecting significant morphological and pathophysiological differences between the two LMH groups.

Precis:

This study analyzed the results of pars plana vitrectomy in the treatment of tractional and degenerative lamellar macular holes (LMH). Functional improvements were higher in the tractional subgroup. Complete postoperative anatomical restoration was described in the majority of the tractional LMH but not in the degenerative subtype.

Introduction

The diagnosis "lamellar macular hole" (LMH) currently includes a heterogeneous group of macular lesions which share common morphologic features such as partial thickness defects in the fovea, irregular foveal contour, and characteristic autofluorescence patterns.[1,2]

Since the original LMH characterization by Gass in 1976, major advances in imaging techniques led to a transformational change in our understanding of this pathology.[3] Specifically, the introduction of high-definition spectral-domain optical coherence tomography (SD-OCT) technology allowed clinicians to study *in-vivo* LMH with an unprecedented level of detail.[1]

However, with SD-OCT the distinction between LMH and other macular conditions such as macular schisis or pseudohole became controversial.[4] Consequently, the definition itself of LMH is not uniform in the literature, and it changed in parallel with the improvements in SD-OCT imaging.[5]

Recently, Govetto et. al proposed the distinction between two subtypes of LMH, tractional and degenerative, arguing that they may represent different pathologic conditions with equally different clinical implications.[5] The degenerative LMH has a "top hat" morphology on SD-OCT and it is characterized by the frequent presence of a "thick" or "dense" premacular membrane (PMM), recently renamed lamellar macular hole associated epiretinal proliferation (LHEP) by Pang et al.[6] This subtype of LMH is also characterized by intra-retinal cavitation potentially involving all retinal layers and by early compromise of the foveal photoreceptors (figure 1, A). Tractional LMH is characterized by a "moustache" appearance on SD-OCT. This subtype of LMH is defined by a sharp split at the level of the Henle fiber layer and by the presence of a "classic" PMM, while foveal photoreceptors are often spared (figure 1, B).

Up to date, there is no consensus regarding the treatment of tractional and degenerative LMH, and the published data is insufficient to warrant any clear recommendation.[5] However, observation may often be preferred to surgery, as these lesions were shown to be relatively stable over time.[5,7]

Surgical intervention with pars plana vitrectomy (PPV), PMM or LHEP peel may be considered in cases of symptomatic visual acuity deterioration or anatomical progression.[7] However, few studies have investigated the surgical outcomes of PPV in eyes with LMH, and the published results are somewhat controversial, particularly in those lesions with LHEP.[8-10] In fact, while dell'Omo et al. and Lai et al. reported that the presence of LHEP does not seem to influence the natural course of LMH and the response to surgery,[8,9] their conclusions were not confirmed in a subsequent study by Ko et al.[10]

Therefore, this study performed an in-depth analysis of both functional and anatomical surgical results in a group of patients diagnosed with tractional and degenerative LMH who underwent PPV with PPM or LHEP peel, with a minimum follow up of 6 months.

Material and methods:

This study was approved by the Institutional Review Boards of the Ramon y Cajal University Hospital (Spain), the Sunderland Eye infirmary (UK), the University of California Los Angeles (USA). This research project adhered to the tenets of the Declaration of Helsinki and was designed in compliance with the Health Insurance Portability and Accountability Act regulations.

A retrospective, observational, and consecutive review of the clinical records and SD-OCT images of patients diagnosed with either tractional or degenerative LMH and evaluated by four retina specialists (M.S.F., D.S., J.S. and J.P.H.) between January 1, 2010 and January 1, 2017 at the the Ramon y Cajal University Hospital, the Sunderland Eye infirmary, the Stein Eye Institute and the VMR institute was performed. In all the participating centers but two, cases were identified by a medical billing record search, using the International Statistical Classification of Diseases and Related Health Problems, Ninth Revision (ICD-9) diagnosis codes 362.56 for macular pucker and 362.54 for macular cysts, holes, and pseudoholes. At the Ramon y Cajal University Hospital (Spain) and at the Sunderland Eye Infirmary (UK) the search was carried out manually using proprietary medical database.

Inclusion criteria included the presence of tractional and degenerative LMH treated with PPV, PMM/LHEP peel, with a minimum follow up of 6 months and preoperative and postoperative SD-OCT imaging. Exclusion criteria were history of advanced age-related macular degeneration, advanced glaucoma, diabetic retinopathy and other vascular retinal diseases, myopic choroidal neovascularization, macular telangiectasias, retinal dystrophies, uveitis and intraocular infections, trauma, and any previous intraocular surgery apart from uncomplicated phacoemulsification.

Comprehensive ophthalmologic exams included best-corrected visual acuity (BCVA) assessment, measurement of intraocular pressure, slit-lamp biomicroscopy, and fundus examination. BCVA was recorded at each visit, reported in Snellen fraction and then converted into logarithm of the minimal angle of resolution (logMAR) values for statistical analysis.

SD-OCT images were obtained with either the Spectralis OCT with eye-tracking dual-beam technology (Heidelberg Engineering GmbH, Heidelberg, Germany) or with the Cirrus HD-OCT 5000 (Carl Zeiss Meditec AG, Oberkochen, Germany) or the Optos SD-OCT/SLO (Optos, Marlborough, Mass, USA). Spectralis OCT scans were analyzed with the Heidelberg Eye Explorer (version 1.8.6.0) using the HRA/Spectralis Viewing Module (version 5.8.3.0), while Cirrus OCT scans were analyzed with the Cirrus review software Version 8.0.

With Spectralis OCT, at each visit all eyes were imaged with at least 2 type of SD-OCT scan patterns: 19 B-scans administered over an area of 20 X 15 degrees with each B-scan spaced 242 µm apart and a single high-definition horizontal B-scan at 30 degrees. In addition, some of the included eyes underwent high-density scanning over a macular area of either 15 X 10 degrees with 97 B-scan each spaced 31 µm apart, or 15 X 5 degrees with 131 B-Scan spaced 11 µm apart. With Cirrus OCT, each eye was imaged with the Macular cube 518 x 128 scans and with the HD 5-line raster.

Mean central foveal thickness (CFT) values were obtained automatically by the Heidelberg, Zeiss, and Optos proprietary software.

Tractional and degenerative LMH were identified with SD-OCT, and were defined according to Govetto et al. as illustrated in figure 1.

With SD-OCT, “classic” PMM were defined as single, irregular, and hyper-reflective lines above the inner limiting membrane (ILM), often associated with signs of traction (retinal wrinkling) and with the occasional presence of hypo-reflective spaces between the PMM and ILM (figure 2, A). LHEP was defined as a thick and uniform iso-reflective material located above the ILM, covered by a thin hyperreflective line without signs of wrinkling on the underlying retina and without the presence of hypo-reflective spaces between LHEP and the ILM (figure 2, B).

Intraretinal cavitation was defined with SD-OCT as the presence of confluent and roundish hyporeflective intraretinal spaces potentially involving all retinal layers, with the occasional presence of septations of residual retinal tissue. Intraretinal schisis was define with SD-OCT as a sharp separation between inner and outer retinal layers with a split located between the outer nuclear layer (ONL) and outer plexiform layer (OPL), at the level of the Henle fiber layer. Intraretinal schisis was also characterized by the presence of multiple hypo-reflective intraretinal cystoid spaces, separated by hyper or iso-reflective bridges of retinal tissue.

The presence of a discontinuous ellipsoid or external limiting membrane (ELM) band in the foveal region was considered a sign of photoreceptor compromise and outer retinal disruption.

All patients underwent a standard, three ports 23 or 25-Gauge PPV with PMM or LEHP peel performed by four vitreo-retinal surgeons (M.S.F, D.S., J.S., J.P.H.) with the Constellation vision system (Alcon, Fort wort, TX, USA). ILM removal and combined phacoemulsification procedures were performed at the discretion of the surgeon. Core vitrectomy was performed in all cases. After the creation of posterior vitreous detachment, ILM forceps were used to peel the PMM/LHEP and, in some cases, the ILM up to the vascular arcades. Based on the surgeon’s discretion, the use of either intraocular Kenalog (Bristol-Myers Squibb, Irvine, CA, USA), Brilliant blue G (DORC, Zuidland, The Netherlands) or indocyanine green (ICG) was applied over the retinal surface to enhance visualization during ILM peeling. At the end of the surgery, the eyes were filled with balanced saline solution (BSS), air, octafluoropropane (C3F8), or sulfur-hexafluoride (SF6).

All patients were evaluated at least at 1 and 6 months after surgery, and potential post-operative complications were recorded at any time point during the follow up period.

Post-operatively, primary anatomical success was defined as the absence of breaks in the inner fovea and the disappearance of either intraretinal cavitation or macular schisis (i.e. absence of any intraretinal hyporeflective spaces as seen with SD-OCT) after a single surgical procedure.

Two post-operative healing patterns were described: delayed and immediate. The delayed healing was defined as persistence of intraretinal hyporeflective spaces in the foveal region after the first month from surgery, with their progressive disappearance during the follow-up period (figure 3). The immediate healing was defined as the complete disappearance of any intraretinal hyporeflective space in the foveal region at one month from surgery (figure 4).

Mean and standard deviation values were calculated for continuous variables, while frequency and percentage were calculated for categorical variables. Student's t-test was used to compare the statistically significant difference in continuous measurements among all subgroups, Chi-square test was used to compare proportions among the study population. The association of SD-OCT parameters with BCVA was assessed by means of univariate and multivariate linear or logistic regression, as appropriate. Log-rang test was used to compare the survival functions of the two subgroups of LMH (i.e. anatomical restoration) in Kaplan-Meier survival curves. All analyses were conducted using Stata 15.1 software (StataCorp, College Station, TX, USA).

Results

Preoperative findings:

After the review process, this study enrolled 103 eyes of 103 patients, of which 38 were males (37%) and 65 were females (63%) with a mean age at surgery of 67 ± 8.9 years (range 31-89) and a mean follow-up of 30.8 ± 28.8 months (range 6-96 months). At presentation, 52 out of 103 eyes (50.5%) were phakic, while the remaining 51 (49.5%) were pseudophakic.

Preoperatively, tractional LMH was diagnosed in 77 out of 103 eyes (74.8%), while degenerative LMH was diagnosed in 26 out of 103 eyes (25.2%) without significant differences in gender and age between the two LMH subgroups.

Preoperatively, mean BCVA in the tractional subgroup was 0.39 ± 0.2 LogMAR (20/50 Snellen equivalent), while in the degenerative subgroup was 0.56 ± 0.2 LogMAR (20/72 Snellen equivalent), being the difference between the two LMH subtypes statistically significant ($p<0.001$).

Preoperatively, a classic PMM was present in all tractional LMH (77 out of 77 eyes, 100%), while LHEP was found in all degenerative LMH (26 out of 26, 100%). In only 1 out of 77 eyes with tractional LMH the simultaneous presence of PMM and LHEP was noticed. No PMM was diagnosed in degenerative LMH eyes.

Preoperatively, 13 out of 26 eyes (50%) diagnosed with degenerative LMH presented with outer retinal disruption, which was present in only 11 out of 77 eyes (14.3%) diagnosed with tractional LMH. The difference between the two LMH subgroups was statistically significant ($p<0.001$).

Preoperatively, in the tractional LMH subgroup the mean CFT was thicker if compared with the degenerative LMH subtype (279.1 ± 108 µm, range 254-303 µm versus 224 ± 66 µm, range 197-250 µm) with a statistically significant difference ($p=0.016$).

Surgical intervention:

Twenty-three-gauge PPV was preferred in most of the cases (85 out of 103 eyes, 82.5%), while in the remaining 18 eyes (17.5%) 25-gauge PPV was performed.

Combined phacoemulsification with intraocular lens implantation was performed in 13 out of 103 eyes (12.6%).

Double peeling of PMM/LHEP and ILM was performed in the vast majority of eyes (99 out of 103 eyes, 96.1%), while in the remaining 4 cases (3.9%) just the PMM was removed. The ILM was stained with Brilliant Blue G in 66 out of 99 cases (66.6%), and with ICG in 16 out of 99 eyes (16.2%), while in the remaining 15 eyes (15.2%) no dyes were used.

Fifteen out of 103 eyes (14.6%) were filled with BSS at the end of the surgery. Gas tamponade with C3F8 was performed in 32 out of 103 eyes (31.1%), while in 31 out of 103 eyes (30.1%) SF6 tamponade was preferred. The remaining 25 eyes (24.2%) were partially filled with air.

Intraoperative complications (i.e. iatrogenic retinal break during ILM peel and a choroidal detachment) were registered in 2 out of 103 eyes (1.9%).

Postoperative anatomical outcomes:

Postoperatively, primary anatomical success was achieved in 97 out of 103 eyes (94.2%), in which either intraretinal cavitation or macular schisis disappeared after PPV. Surgical intervention was not able to achieve foveal restoration in 5 tractional LMHs and in 1 degenerative LMH (5.8%), in which there was persistence of the intraretinal cavitation/macular schisis until the end of the follow up period. The Kaplan-Meier estimate of the probability to miss primary anatomical success was 36% (95%CI: 27-45%) at 1 month, 17% (95%CI: 10-24%) at 6 months and 3% (95%CI: 0-8%) for those LMH with 12 months follow-up.

Postoperatively, healing patterns differed significantly between the two LMH subtypes ($p < 0.001$). The delayed healing was more frequent in tractional LMH, while the immediate healing was prevalent in the degenerative subtype as illustrated in figure 3 and 4. Kaplan-Meier survival analysis confirmed significant differences between tractional and degenerative LMH ($p=0.025$) as illustrated in figure 5, A: the tractional subtype appeared to heal more slowly after surgery (mean time to primary anatomical success 3.3 ± 3.6 months, range 1-14 months) as compared to the degenerative group (mean time to primary anatomical success 1.6 ± 2.3 months, range 1-12 months).

Postoperatively, outer retinal disruption resolved in 7 out of 24 eyes (5 tractional and 2 degenerative, 29.2%), while in the remaining 17 eyes (6 tractional and 11 degenerative, 70.8%) ellipsoid and/or ELM alterations persisted up to the end of the follow-up period.

The type of tamponade did not significantly change the postoperative anatomical success rate and LMH healing time ($p=0.064$) using Kaplan-Meier survival analysis did not reveal significant differences between air, gas or BSS tamponade, as illustrated in figure 5, B.

The rate of postoperative complications was low, as they were registered in 5 out of 103 eyes only (4.8%); in 3 of them (two degenerative and one tractional LMH), full thickness macular hole developed after a mean follow-up of 8 ± 1.7 months. In the remaining 2 eyes, both degenerative LMH, a rhegmatogenous retinal detachment developed 6 months after surgery. In both cases retinal breaks were located in the periphery, without macular involvement.

Postoperative functional outcome and correlations with SD-OCT parameters

Postoperatively, BCVA improved in both tractional and degenerative LMH (p<0.001 and p=0.012, respectively) as illustrated in figure 6. However, at the end of the follow-up period of 30.8 ± 28.8 months, BCVA differences between the two LMH subgroups remained significant (p<0.001). After adjusting for preoperative BCVA, there was a significant difference in postoperative visual acuity improvement between tractional versus degenerative LMH (p=0.006), with the tractional subtype characterized by the higher BCVA recovery.

Having delayed, rather than immediate healing was not associated with significant differences in postoperative visual recovery, even adjusting for baseline BCVA (p=0.118). In eyes with delayed healing, BCVA improved significantly with the disappearance of the break in the inner fovea (p=0.002) and continued to increase with the disappearance of the intraretinal schisis/cavitation up to the end of the follow up period (p=0.001). In both univariate and multivariate logistic regression models, worse preoperative BCVA and preoperative outer retinal disruption were significantly associated with lower postoperative visual recovery (p<0.010 for all coefficients).

Discussion

The optimal management of patients diagnosed with LMH is controversial, and observation is often preferred to surgery due to the relative anatomical and functional stability of such lesions.[2,5] However, a more interventional attitude may be necessary in those lesions with signs of anatomical and/or functional deterioration, or if preoperative vision is causing significant disability.[2,8-10]

This study analyzed the postoperative functional and anatomical outcomes of PPV in a large series of patients diagnosed with tractional and degenerative LMH, and found high rates of anatomical restoration and significant visual improvement in both LMH subtypes. However, such improvements were significantly higher in the tractional, as compared to the degenerative subgroup. This fact is not surprising; in our series degenerative LMH were characterized by worse preoperative BCVA and higher rates of preoperative ellipsoid/ELM disruption, in accordance with previous reports.[2,5,8-13] Such preoperative features are robust indicators of worse postoperative functional improvement in macular surgery.[14]

In the published literature, postoperative findings in LMH are heterogeneous: Dell'Omo and associates and Lai et al. reported that the presence of LHEP does not seem to influence the natural course of the disease or the response to surgery, if compared with eyes without LHEP.[8,9] Contrastingly, Ko et al. found no significant postoperative improvement in BCVA in eyes with LMH and LHEP.[10] The variability of such results may be due to the absence of consensus on the definition and classification of LMH, which complicates inter-study comparisons.[5]

The diverse postoperative healing patterns (i.e. delayed versus immediate) seen in tractional and degenerative LMH may be explained by the morphological and pathophysiological differences between these lesions.

In degenerative LMH, there is not a mechanical separation between inner and outer retina, but rather loss of retinal tissue due to poorly defined pathophysiological mechanisms, with the subsequent accumulation of LHEP in the foveal region.[5] With the removal of the ILM and the LHEP, the residual inner retinal tissue is free to settle over the foveal floor, with the disappearance of cavitations (immediate healing illustrated in figure 3).

In tractional LMH, mechanical forces exerted by the PMM onto the inner retinal surface cause the elongation and verticalization of the axons of the Müller cells in the

Henle fiber layer, resulting in a schitic morphology.[5] With PPV, PMM and ILM peel such tractions are relieved, and the axons of the Müller cells can slowly return to their original morphology, with the restoration of macular anatomy and the disappearance of the macular schisis (delayed healing, illustrated in figure 4).

In the present study, qualitative analysis of the postoperative foveal microstructure also showed significant differences between the two subtypes of LMH. After surgery, in the majority of tractional LMH the foveal microstructure recovered almost completely, without sign of disruption of retinal layers and/or apparent tissue loss (figure 4). This confirms the hypothesis that tractional LMH are characterized by displacement rather than loss of retinal tissue.[4,5]

Contrastingly, postoperative foveal microstructure was different in degenerative LMH. The appearance of retinal layers in the foveal and parafoveal region was altered and disrupted in the majority of cases, as reflection of the loss of retinal tissue that distinguishes these lesions (figure 3). In degenerative LMH the cavitation loss was replaced by mid reflective material on OCT, similar to LHEP.

Limitations of our study include its retrospective nature, which may have caused some bias. Moreover, this was not a single-surgeon series, a fact which could have caused data heterogeneity. Also, no imaging of the vitreo-papillary interface was undertaken, although previous studies identified a higher prevalence of vitreo-papillary adhesion (VPA) in LMH than macular pucker, but lower than full-thickness macular holes.[15,16] Future studies should explore the relative prevalences of VPA in tractional vs. degenerative LMH and integrate this information into our fund of knowledge about these two LMH subtypes.

Strengths of our work include the adequate size of the study population, which increased the power of our statistical analysis, and the length of the follow up period.

To conclude, this study analyzed the anatomical and functional results of PPV with PMM/LHEP peel in a large series of tractional and degenerative LMH. BCVA improved significantly in both subtype of LMH, although functional improvements were higher in the tractional LMH. Two healing patterns were described: delayed and immediate. The first was common in the tractional LMH, while the latter was characteristic of degenerative LMH. Complete postoperative anatomical restoration of foveal microanatomy was described in the majority of the tractional LMH but not in the degenerative subtype, reflecting significant morphological and pathophysiological differences among the two LMH groups.

The results described herein support the current trend of thought which considers tractional and degenerative LMH as two distinct clinical entities.[4,5] The negligible tissue loss in the tractional subgroup led some authors to claim that these lesions might even be considered as macular pseudoholes with lamellar cleavage.[4]

Further larger and prospective investigations are needed to reduce bias and to better understand the effectiveness of surgical treatment with PPV with PMM/LHEP peel for both tractional and degenerative LMH. Moreover, collaborative cooperation among clinicians is needed to achieve a broader, universal consensus on the definition of LMH and ultimately improve the management of these lesions.

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FIGURE CAPTIONS:

Figure 1: Degenerative and tractional lamellar macular holes. A: Degenerative lamellar macular hole. This subtype of lamellar macular hole has a “top hat” morphology and it is associated with the presence of the lamellar macular hole associated epiretinal proliferation. These lesions present with intraretinal cavitation, potentially affecting all retinal layers. A foveal “bump” of spared retinal tissue is frequently present, as well as outer retinal disruption. **B. Tractional lamellar macular hole.** This subgroup of lamellar macular hole has a “moustache” morphology, and it is associated with the presence of “classic” premacular membranes. These lesions present with a “schitic” morphology, with a sharp split located in the Henle fiber layer, which separates inner and outer retina. Foveal photoreceptors are frequently spared.

Figure 2: Differences between premacular membrane and lamellar macular hole associated epiretinal proliferation (LHEP). A. Premacular membrane. A “classic” premacular membrane (white arrows) is visible with spectral-domain optical coherence tomography (SD-OCT) as a sharp hyperreflective line, frequently associated with multiple hyporeflective empty spaces between the membrane and the internal limiting membrane (white star). Sings of wrinkling of the underlying retina are present. **B. LHEP.** Contrastingly, LHEP (black arrows) appears on SD-OCT as a thick isoreflective preretinal formation. The LHEP is always in direct contact with the internal limiting membrane, and no signs of retinal wrinkling are present.

Figure 3: Immediate healing. A. Preoperative appearance. A degenerative lamellar macular hole is diagnosed with spectral-domain optical coherence tomography. **B. Postoperative appearance at 1 month.** The intraretinal cavitation disappeared, but the foveal microstructure appears disrupted.

Figure 4: Delayed healing. A. Preoperative appearance. A tractional lamellar macular hole is diagnosed with spectral domain optical coherence tomography (SD-OCT). **B. Postoperative appearance at 1 month.** The foveal break closed, but intraretinal cystoid spaces are still visible with SD-OCT. **C. Postoperative appearance at 2 months.** Foveal thickness decreased, intraretinal cystoid spaces reduced, but are still visible with SD-OCT. **D. Postoperative appearance at 3 months.** At three months, intraretinal cystoid spaces disappeared, and the foveal microanatomy is restored.

Figure 5. Kaplan-Meier survival curves. A. Tractional versus degenerative lamellar macular hole. The delayed healing is common in the tractional subtype, if compared to the degenerative lamellar macular hole. Therefore, the tractional subtype appeared to heal significantly slower after surgery. **B. Healing time according to different intraocular tamponade.** There are no significant differences in healing times among different endotamponade agents.

Figure 6. Preoperative and Postoperative best corrected visual acuity in tractional and degenerative lamellar macular holes. In both tractional and degenerative lamellar macular holes, best corrected visual acuity significantly improved after surgery.

Figure 1

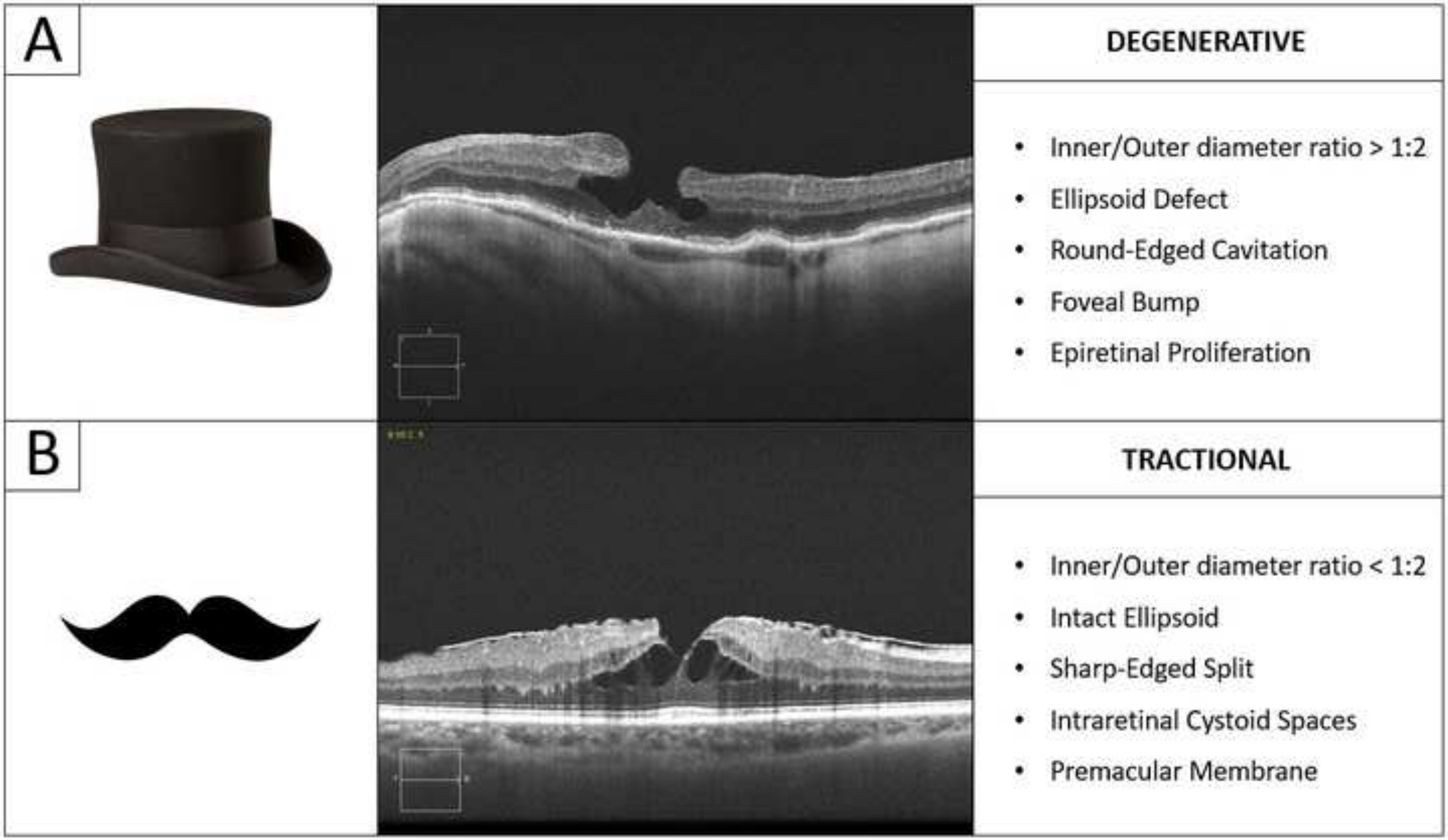

A
DEGENERATIVE
• Inner/Outer diameter ratio > 1:2
• Ellipsoid Defect
• Round-Edged Cavitation
• Foveal Bump
• Epiretinal Proliferation
B
TRACTIONAL
• Inner/Outer diameter ratio < 1:2
• Intact Ellipsoid
• Sharp-Edged Split
• Intraretinal Cystoid Spaces
• Premacular Membrane

Figure 2

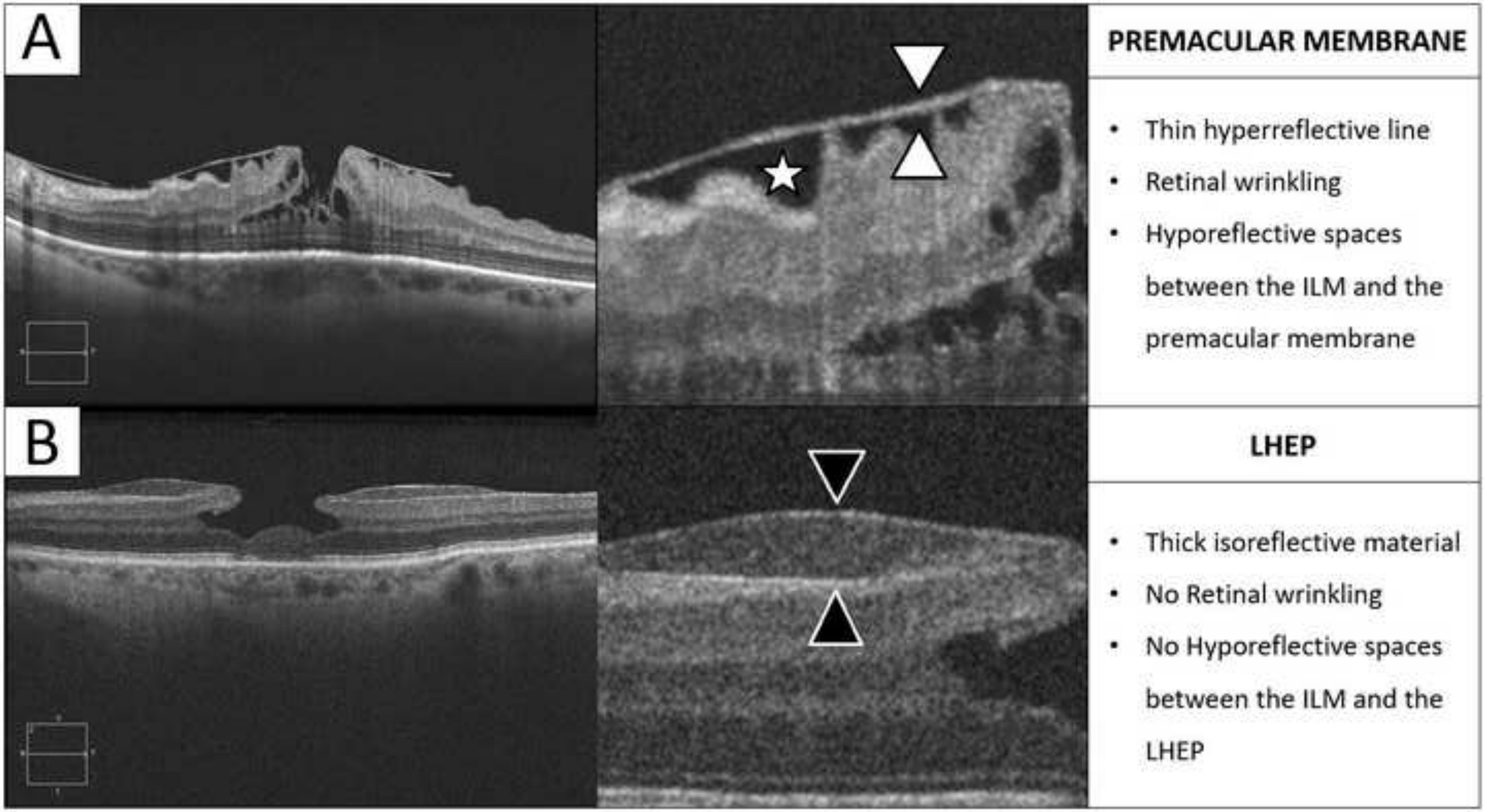

A
B
PREMACULAR MEMBRANE
• Thin hyperreflective line
• Retinal wrinkling
• Hyporeflective spaces between the ILM and the premacular membrane
LHEP
• Thick isoreflective material
• No Retinal wrinkling
• No Hyporeflective spaces between the ILM and the LHEP

Figure 3

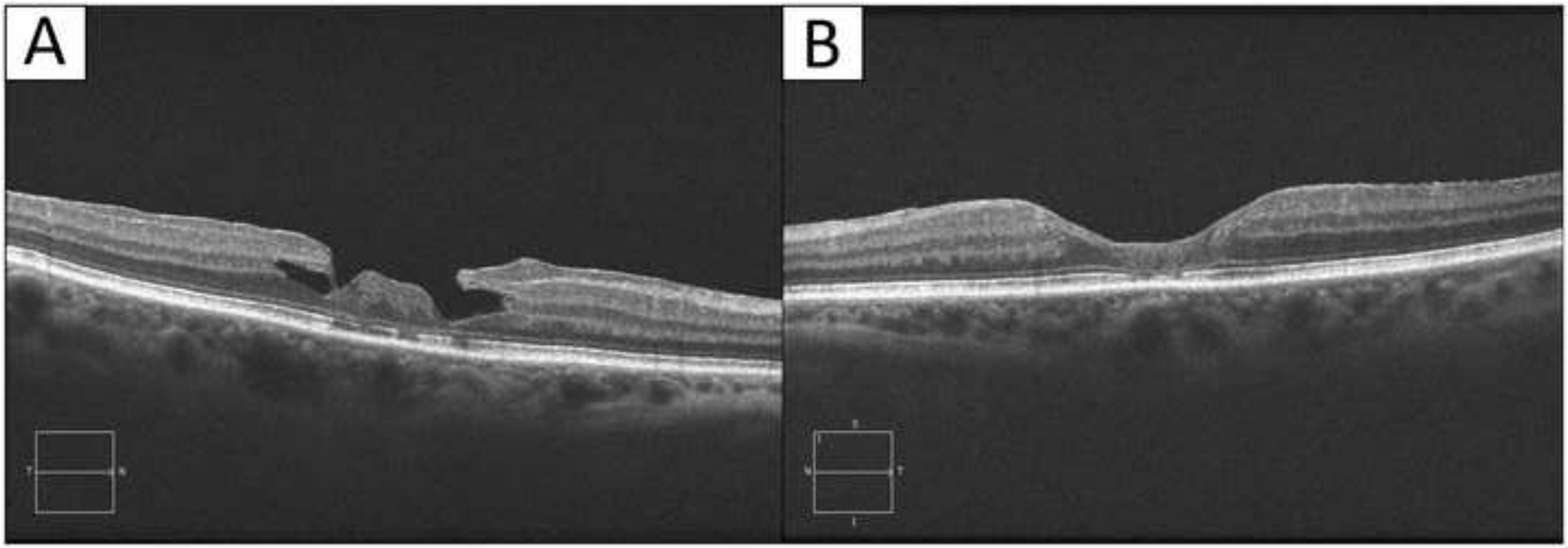


Figure 4

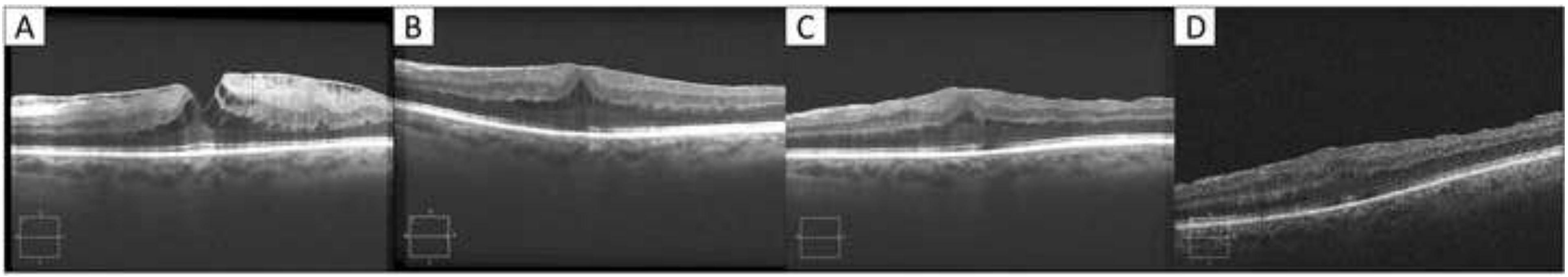
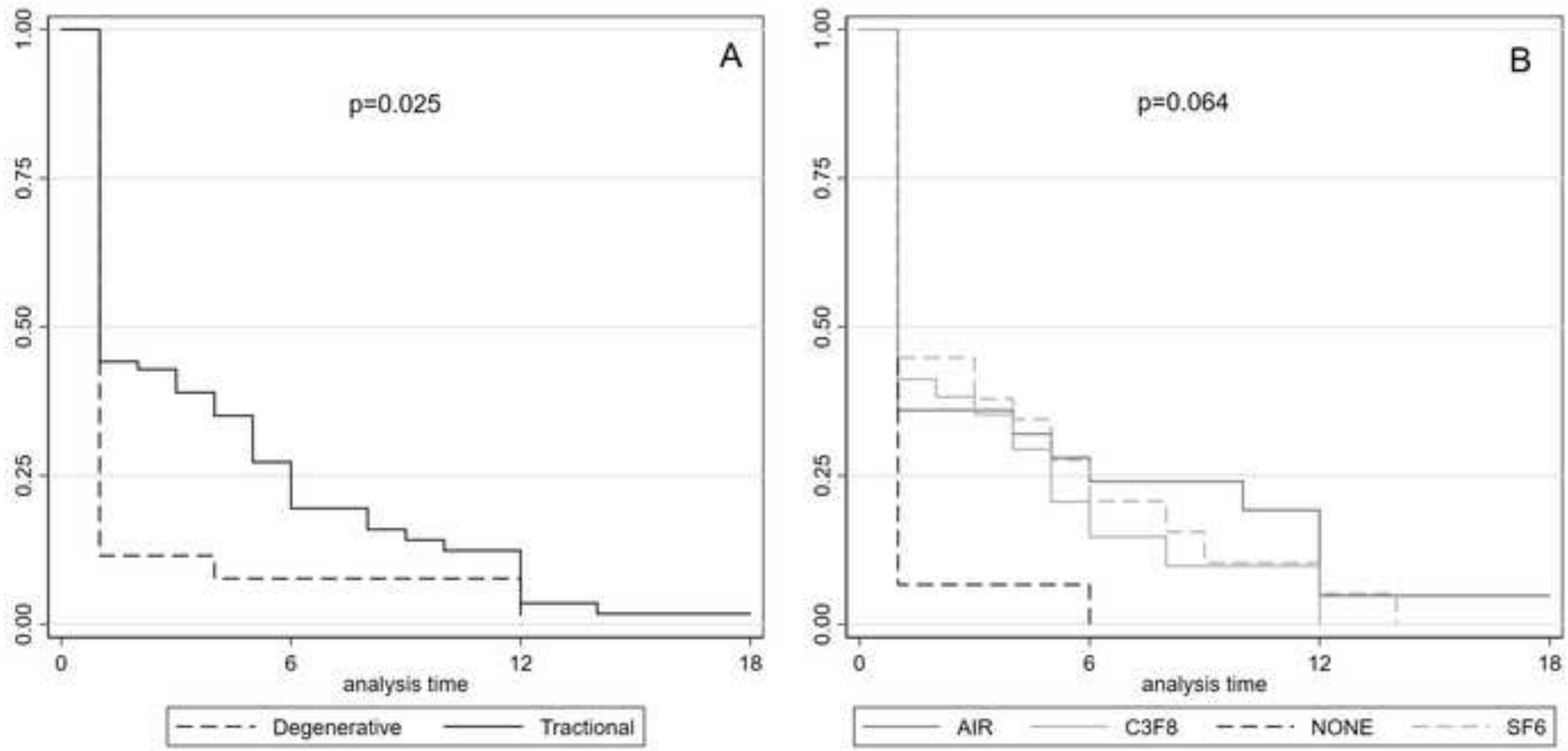
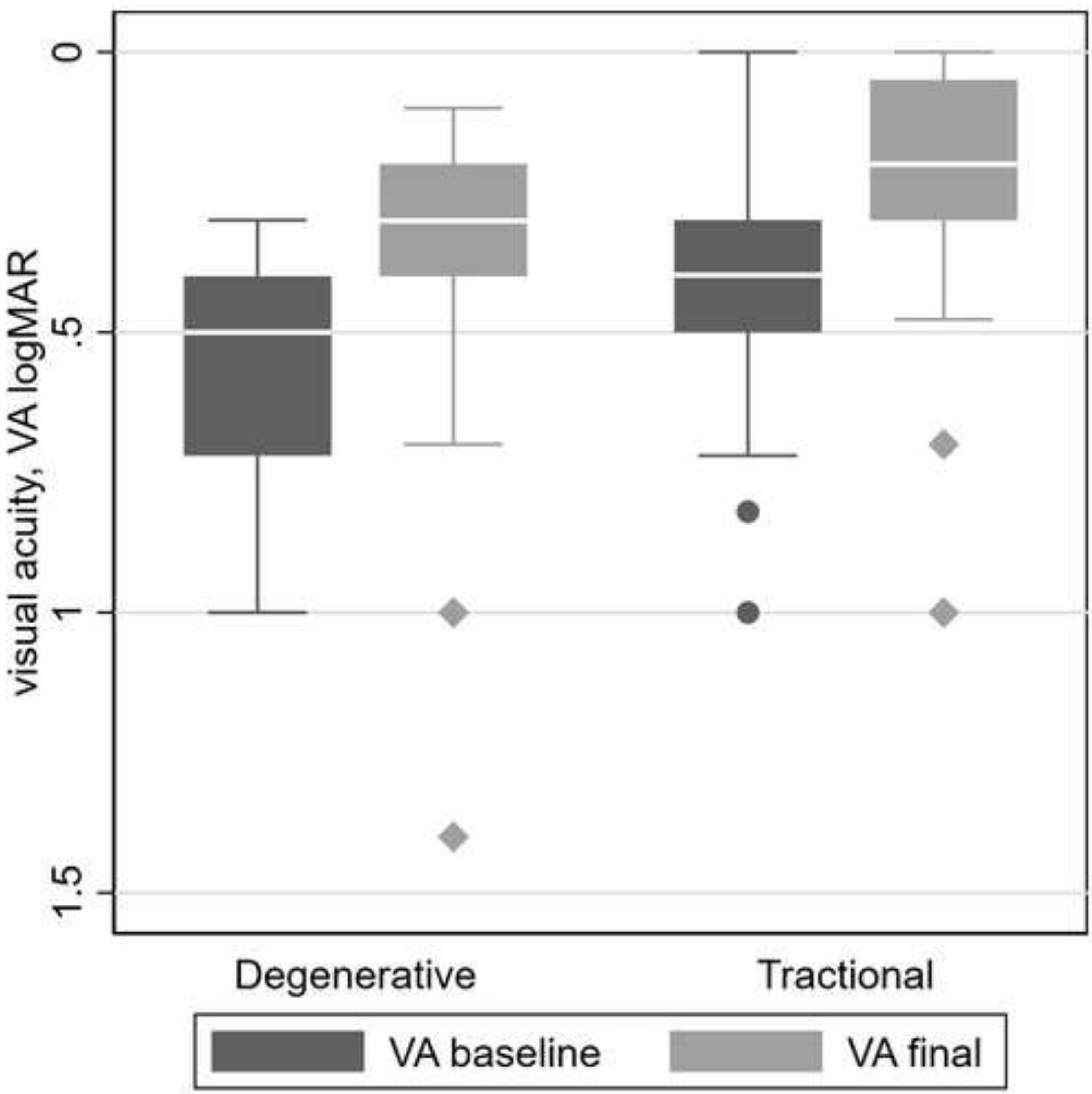


Figure 5



A
p=0.025
1.00
0.75
0.50
0.25
0.00
0
6
12
18
analysis time
Degenerative
Tractional
B
p=0.064
1.00
0.75
0.50
0.25
0.00
0
6
12
18
analysis time
AIR
C3F8
NONE
SF6

Figure 6



0
.5
1
1.5
visual acuity, VA logMAR
Degenerative
Tractional
VA baseline
VA final