Macular changes after uncomplicated phacoemulsification surgery in patients with idiopathic partial-thickness foveal defects

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PURPOSE: To analyze the morphologic changes (based on Optical Coherence Tomography—OCT—examination) and the functional changes (based on determination of Best Corrected Visual Acuity—BCVA—) in patients with the diagnosis of idiopathic partial-thickness foveal defects (Lamellar Macular Hole—LMH—or Macular Pseudohole—MPH—) who underwent routine cataract surgery.

SETTING: Hospital Universitario Central de Asturias and Instituto Oftalmológico Fernández-Vega, Oviedo, Spain.

METHODS: We prospectively analyzed 25 eyes of 23 patients with idiopathic LMH or MPH on OCT examination, who underwent uneventful phacoemulsification due to the presence of cataract. BCVA (logMAR notation), biomicroscopic examination, fundus photography, size of the defects (Diameter, Residual Thickness, and Nasal and Temporal Perifoveal Thickness) measured by OCT, were recorded in all patients, before and after surgery.

RESULTS: Mean BCVA in the total group at baseline was 0.46 ± 0.25 (0.00-1.30), and at final examination was 0.18 ± 0.14 (0.00-0.50), this difference being statistically significant (p<0.001). We did not observe statistically significant differences regarding any of the anatomic parameters between the onset and the end of the study, in the total group (p=0.626, p=0.377, p=0.571, p=0.440, respectively) and neither in the subgroups of LMH and MPH (p>0.05).

CONCLUSIONS: Most of idiopathic LMH and MPH did not progress anatomically (based on OCT) after uncomplicated phacoemulsification, during the follow-up period. Furthermore, a significant improvement in BCVA can be achieved after cataract surgery in patients with LMH and MPH, and this must be taken into account before considering vitreoretinal surgery in these patients.

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Although major progress in modern cataract surgery has been made within the last decades, pseudophakic cystoid macular oedema and macular changes after uncomplicated phacoemulsification in healthy patients are still present. The relevance is probably attributed to the large number of cases that are performed each year. Regarding the pathophysiology, four consecutive steps have to be considered: (i) surgical procedure-related induction and release of various inflammation mediators into the anterior chamber; (ii) removal of the physiological lens barrier between the anterior and
Lamellar Macular Holes (LMH) and Macular Pseudoholes (MPH) are partial-thickness foveal defects which seem to not progress in time, although there is some controversy. This is the reason that a conservative approach (based on observation) is perform in most cases by some authors, although others propose a surgical management based on pars plana vitrectomy.

However, there are no studies that analyze what happens to patients with idiopathic LMH and MPH who underwent conventional and uncomplicated cataract surgery.

The aim of this study is to analyze morphological changes (based on Optical Coherence Tomography examination —OCT—) and the functional changes (based on determination of Best Corrected Visual Acuity —BCVA—) in patients with the diagnosis of idiopathic LMH or MPH who underwent cataract surgery.

**PATIENTS AND METHODS**

We prospectively analyzed 25 eyes of 23 patients with the diagnosis of idiopathic LMH or MPH by means of OCT (Cirrus SD, Carl Zeiss Meditec, Inc.; Dublin, CA, U.S.A.) examination, who underwent uneventful phacoemulsification due to the presence of cataract with functional repercussion. The study was conducted in two hospitals specializing in retinal pathology, and according to the principles of the Declaration of Helsinki. The study was approved by an independent ethic committee (Regional Clinical Investigation Ethics Committee of Asturias).

The OCT-based diagnostic criteria for LMH were the following: irregular thinning of foveal base, break in the inner fovea, intraretinal split (dehiscence of the inner foveal retina from the outer retina), normal perifoveal retinal thickness and absence of a full thickness foveal defect (Figure 1A). The diagnostic criteria for MPH were: partial thickness macular defect, normal central retinal thickness despite the loss of inner layers (explained by an increase in perifoveal thickness), a steepened defect, with verticalized foveal slopes, due to the contraction of an Epiretinal Membrane (ERM), visible in OCT scans (Figure 1B).

Cataract extraction was performed using the Infiniti® Vision System (Alcon Laboratories, Inc.; Fort Worth, TX, U.S.A.). Phacoemulsification was followed by irrigation and aspiration of the cortex and Acrysof® SA60AT monofocal intraocular lens (IOL) (Alcon Laboratories, Inc.; Fort Worth, TX, U.S.A.) implantation in the capsular bag using the injector developed for the IOL. The SRK-T formula for IOL power calculation was chosen in all cases. No intraoperative or postoperative complications occurred.

BCVA (logMAR notation), biomicroscopic examination, fundus photography, and OCT (Stratus or Cirrus) scan (Carl Zeiss Meditec Inc.; Dublin, CA, U.S.A.) were recorded in all patients, before and after surgery.

We considered the following inclusion criteria: patients with the tomographic diagnosis of idiopathic LMH or MPH in the first examination, age ≥ 18 years, and availability for exploratory examinations. As exclusion criteria: presence of macular pathology of any etiology (age-related macular degeneration, diabetic retinopathy, macular dystrophies, etc), and any inflammatory, vascular, or infectious ocular disease.

The following variables were assessed: BCVA and hole size, in terms of Diameter (D), Residual Thickness (RT) and Perifoveal Thickness (PT), measured manually, using the OCT software Caliper, at baseline and final examination. The D was measured taking into account the largest diameter of the hole; RT was determined as the deepest foveal point; and PT was measured in temporal (TPT) and nasal (NPT) retina 200 microns from the foveal centre.

All these patients were followed, each 6 months, with a mean follow-up period of 29.05 ± 17.66 (12-83) months.

The statistical analysis was performed using SPSS for Windows version 15.00. Parametric tests were used.
in order to study the changes in BCVA and the size of LMH and MPH during the follow-up. In all cases we considered p-values of less than 0.05 as statistically significant.

**RESULTS**

We analyzed 25 eyes (18 left eyes and 7 right eyes) of 23 patients, 9 female and 14 male with a mean age of 72.24 ± 6.91 (58-85) years.

According to OCT profiles, 16 were classified as LMH and 9 as MPH. We also observed anatomic macular alterations determined by OCT in the fellow eyes preoperatively, and we found: 3 (12.0%) eyes with LMH (excluding two patients from the study who had bilateral LMH), 4 (16.0%) eyes with ERM, and one (4.0%) eye with a foveal cystic defect.

Before cataract surgery, 18 eyes (68.0%) showed an associated ERM (100% of the MPH, and 9 eyes —56.25%— of the LMH). 9 eyes showed mild alteration of photoreceptor layer (analyzed by OCT) and none of the patients complained about metamorphopsia.

![Figure 2](image_url). Initial and Final Best Corrected Visual Acuity (BCVA; logMAR) in patients with partial thickness defects (idiopathic Lamellar Macular Hole or Macular Pseudohole) who underwent cataract surgery (p=0.000).

![Figure 3](image_url). Hole size evolution during the follow-up period in patients with partial thickness defects (idiopathic Lamellar Macular Hole or Macular Pseudohole). D: Diameter; RT: Residual Thickness; NPT: Nasal Perifoveal Thickness, TPT: Temporal Perifoveal Thickness measured 200 microns temporal to foveal centre. We observed no statistically significant differences before and after cataract surgery.

![Figure 4](image_url). Hole size evolution during the follow-up period in patients with idiopathic Lamellar Macular Hole. D: Diameter; RT: Residual Thickness; NPT: Nasal Perifoveal Thickness, TPT: Temporal Perifoveal Thickness measured 200 microns temporal to foveal centre. We observed no statistically significant differences before and after cataract surgery.

![Figure 5](image_url). Hole size evolution during the follow-up period in patients with idiopathic Macular Pseudohole. D: Diameter; RT: Residual Thickness; NPT: Nasal Perifoveal Thickness, TPT: Temporal Perifoveal Thickness measured 200 microns temporal to foveal centre. We observed no statistically significant differences before and after cataract surgery.
After cataract surgery, 19 (76.0%) eyes showed ERM (one of the LMH developed an ERM grade I two months after surgery). No progression of photoreceptor layer alterations occurred and none of the participants complained of metamorphopsia.

Mean BCVA in the total group at baseline was 0.46 ± 0.25 logMAR (0.00-1.30), and at final examination was 0.18 ± 0.14 logMAR (0.00-0.50), being this difference statistically significant (p < 0.001) (Figure 2). BCVA in LMH and MPH groups are detailed in Table 1. We found slightly better visual acuities for MPH in comparison to LMH, before and after surgery. Patients with alterations in photoreceptor layer showed slightly worse visual acuities than those without damage in this layer (p > 0.05).

Regarding size of the macular defects, most of them showed a maximum D of 400 or more microns (µm) with a mean of 483.48 ± 134.37 (range: 300-804) µm at baseline and 464.36 ± 109.17 (range: 313-673) µm at final examination, being not statistically significant (p = 0.626).

Mean RT was 153.60 ± 32.34 (range: 80-232) µm and 157.88 ± 34.78 µm (range: 100-263) before and after surgery, respectively (p = 0.377).

Mean TPT was 346.92 ± 52.86 (range: 256-485) µm before cataract extraction and 378.64 ± 121.79 (range: 267-758) µm after surgery (p = 0.440).

Mean NPT was 355.15 ± 44.93 (range: 270-437) µm before cataract extraction and 353.50 ± 38.26 (range: 276-413) µm after surgery (p = 0.571) (Figures 3, 4 and 5).

D, RT, TPT and NPT for LMH and MPH values are detailed in Table 2.

Therefore, we did not observe statistically significant differences regarding any of the anatomic parameters between the onset and the end of the study, in the total group and also in the subgroups of LMH and MPH.

Furthermore, we did not find correlation between BCVA and any of the anatomic parameters (p > 0.05).

Interestingly, we observed a spontaneous closure of one LMH at 21 months of follow-up. In no case we observed evolution to full-thickness macular defect or hole (FTMH). In one eye (4.0%) we observed evolution from MPH to LMH, assessed by means of OCT.

### DISCUSSION

Gass primarily identified two sorts of partial-thickness macular defects and differentiated them into LMHs and MPHs. He believed that LMHs were an abortive process in macular hole formation in the course of macular cystoid edema and that macular pseudoholes were created because of constriction of epiretinal membranes. Gass hypotheses were partially confirmed with the early OCT devices. In OCT, LMHs were defined as partial thickness macular holes with dehiscence of inner from outer retinal layers.
in the fovea and decreased central retinal thickness. In some cases, epiretinal membranes were noted. Photoreceptor layer defects were not observed.

Macular pseudoholes were defined in OCT as partial-thickness defects with a steep foveal contour, normal central retinal thickness, no photoreceptor defects, coexisting epiretinal membrane, and usually only slightly distorted visual acuity (Haouchine et al. criteria).

However, nowadays, other than for academic or research purposes, there is little point in differentiating between subtypes of non-full thickness or partial thickness macular defects, as subtypes can spontaneously change from one to another, they may even appear in sequential scans on the same OCT exploration for one patient, and photoreceptor layer defects can be associated with both of them.

LMH and MPH are associated with good visual acuities, although there are some factors that may influence on visual acuity. Michalewska et al. consider the photoreceptor layer defect as the most important factor correlating with visual acuity. In our study, we did also found that patients with damage of this layer had slightly worse visual acuities. Other authors, such as Chen, state that the retinal thickness and the outer diameter of the fovea defect are the most important factors correlating with visual acuity. On the contrary, we did not find correlation between these parameters and visual acuity.

There is controversy regarding their treatment: surgical (based on vitrectomy) versus conservative management. However, a conservative approach (based on observation) is perform in most cases by some authors.

If we perform a conservative management, just observing periodically these defects, and if we take into account the high average patient’s age (more than 65 years), we will have to face the problem of the presence of an opacified lens, and, consequently the need for cataract surgery. This is why it is essential to know if phacoemulsification can induce a progression of these defects or not.

There are no published papers considering this aspect. Anyway, there exist a large number of publications related to macular changes (cystoid macular edema, epiretinal membrane, macular hole, etc.) after uncomplicated cataract surgery.

It is well known that phacoemulsification, even when uneventful, may have an impact on the healthy retina. In our opinion, this could be attributed to factors such as intraoperative photo stress due to the microscope light, intraoperative changes of the ocular pressure caused by surge or to the ultrasound energy delivered, inflammation induced by the surgical trauma, with increased release of VEGF and interleukin-6, and also vitreous tractions following removal of the lens.

Posterior vitreous detachment (PVD) progression during phacoemulsification has been described because of the entrance of liquefied vitreous into the subhyaloidal space and subsequent dissection of remaining adhesions between the posterior vitreous cortex and the ILM with eye movements. Furthermore, after cataract surgery, the progression of PVD is accelerated by the increased anterior-posterior traction force combined with accelerated vitreous liquefaction attributable to light-induced reactive oxygen species and decrease of protein concentration.

Some authors pointed out that during an uneventful phacoemulsification an important amount of fluid passes through the zonules from the anterior chamber to the vitreous cavity, and this fluid could cause a hydrodissection of the anterior hyaloid; an anterior vitreous detachment can occur with hydration of the vitreous, that leads to the development of anatomic and biochemical changes including liquefaction, which may help explain the mechanism of PVD, and consequently, the development of macular changes.

Kecik et al. evaluated changes in the macular thickness and volume using OCT in patients after phacoemulsification and intracapsular implantation of a foldable IOL, and they concluded that uncomplicated cataract phacoemulsification is followed by increases in the central retinal thickness, foveal volume and volume of the entire macula at days 30 and 90 and at 12 months postoperatively.

Kusbeci et al. showed similar results to the previous authors. They evaluated the central macular thickness after uncomplicated phacoemulsification surgery. They appreciated a significant increase in perifoveal macular thickness measurements in the temporal, nasal, superior and inferior quadrant at postoperative 12th weeks. However, in our study, we did not find significant differences in macular thickness (RT, TPT, NPT) and diameter before and after phacoemulsification, during the follow-up time (29.05 ± 17.66 months).

The progression of ERM after phacoemulsification has also been studied, due, fundamentally, to vitreous tractions over the ERM during the procedure. Jahn et al. conducted a prospective study which demonstrated that the prevalence of ERM increased by 71.4% during the first 6 months after uneventful extracapsular cataract extraction with posterior chamber IOL implantation. Thereafter, the prevalence remained about the same.

However, other authors such as Hayashi et al. consider that progression of idiopathic ERM is not accelerated by phacoemulsification surgery. Forty-three consecutive eyes with idiopathic ERM that...
underwent this procedure were recruited, and 41 consecutive eyes with ERM that did not under- go surgery served as controls. They obtained no significant differences in the foveal thickness and macular volume between the two groups at baseline. The foveal thickness gradually increased by 7.0% in the cataract surgery group and by 5.3% in the no surgery group at 12 months after surgery. When comparing the groups, no significant differences were found in the foveal thickness, macular volume, or their percentage increases, from baseline throughout the 12-month follow-up period.

In our study, before surgery, 18 eyes (68.0%) showed an associated ERM (all of the MPH, and 9 of the LMH). After cataract surgery, 19 (76.0%) eyes showed ERM, with only one of the LMH developing a newly formed ERM grade I two months after surgery. Some authors have reported the development of macular holes\(^{19}\) and lamellar macular holes\(^{2,20}\) after routine cataract surgery. No cases of progression in size of any LMH or MPH after surgery were appreciated in our study, and none of these partial-thickness defects developed into a FTMH during the follow-up period.

However, our results are not intended to be comparable with those previously mentioned in studies performed by other authors as, to our knowledge, this is the first study which analyzes the macular changes after uncomplicated phacoemulsification in patients with idiopathic LMH or MPH.

One limitation of this study is that vitreous adherence was not analyzed. Probably, most of our patients had a posterior vitreous detachment before cataract surgery, as this is a common finding in patients with non-full thickness macular holes\(^{21}\), and this fact may have contributed to the low incidence of macular changes after phaco.

In conclusion, according to our results, most of idiopathic LMH and MPH do not progress anatomically (based on OCT) after uncomplicated phacoemulsification, during the follow-up period. Furthermore, a significant improvement in BCVA can be achieved after cataract extraction in patients with LMH and MPH, and this must be taken into account before considering vitrectomy surgery as an option to treat these macular defects. Vitrectomy should be indicated in cases with substantially diminished visual acuity (not related to other causes, such as the presence of cataract) and/or intense metamorphopsia, which is usually related to moderate or severe photoreceptor layer damage. If we have a mild alteration in photoreceptor layer and cataract, as happened in our patients, we may try cataract extraction as first option in order to improve visual acuity.

Further studies with a large number of patients should be done to confirm or refute these findings.

REFERENCES