Choroid Involvement Secondary to Optic Disc Pit Maculopathy: OCT Analysis and Evolution After Surgical Treatment

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• PURPOSE: To assess choroidal changes associated to optic disc pit maculopathy (ODP-M) and their evolution after surgical treatment.

• DESIGN: Multicentric retrospective case series.

• METHODS: An analysis of 42 patients affected by unilateral ODP-M undergoing surgical treatment between 2013 and 2023 was conducted. Optical coherence tomography (OCT) was performed at baseline and postoperative months 1, 6, 12, and 24 and most recent follow-up. Subfoveal choroidal thickness (SFCT) and peripapillary choroidal thickness (PPCT) were measured in ODP-M and fellow eyes. The presence of retinal pigmented epithelium (RPE) atrophy was used to distinguish between "early" and "advanced" disease, and data regarding fluid localization were collected.

• RESULTS: Baseline SFCT in ODP-M eyes was significantly higher than fellow eyes (386.8 ± 88.9 vs 334.4 ± 72.2 μm, $P = 0.002$), in contrast to PPCT (192.6 ± 47.8 vs 181.2 ± 45.7 μm, $P = .46$). SFCT significantly decreased 1 month postoperatively (mean reduction 36.5 μm, $P = .009$) and remained below preoperative values throughout the follow-up, showed a mean reduction of 79.4 μm at final follow-up ($P < .001$). Conversely, PPCT showed no changes between preoperative and postoperative values (all $P > .05$). Nine eyes (21.4%) showed submacular dilated choroidal vessels, correlated with the presence of subretinal fluid ($P = .008$) and reducing in caliber after surgical treatment. The 10 eyes (23.8%) with advanced disease had lower baseline SFCT and worse best-corrected visual acuity compared to the early disease subgroup, and showed a delayed reduction of choroidal swelling postoperatively.

• CONCLUSIONS: Subfoveal choroid may thicken and remodel in response to ODP-M, eventually returning to physiological values after surgical treatment. Moreover, the presence of RPE atrophy may influence retino-choroidal balance. Conversely, PPCT did not show comparable modifications. (Am J Ophthalmol 2025;270: 120–130.

Optic disc pits (ODPs), oval-shaped depressions generally located in the temporal region of the optic disc, are often congenital but may sometimes arise as a side effect of glaucoma and myopia.[1] ODP is present in 2 in 10,000 people, being unilateral in 85% of cases.[2,3] Of the patients, 25% to 75% develop so-called ODP maculopathy (ODP-M).[4]

Often manifesting during the second or fourth decade of life, ODP-M is characterized by the presence of intraretinal or subretinal fluid in varying combinations. Despite the pathophysiology being unclear, this fluid was hypothesized to originate from the vitreous or the cerebrospinal fluid.[5,6] There might be a range of presentations for this fluid buildup, as demonstrated with optical coherence tomography (OCT). It may result in a schisis-like separation of retinal layers, usually in the outer layers, or it may merely exist as subretinal fluid. Furthermore, fluid may sometimes involve more than 1 layer of the retina, or may cause the development of outer lamellar holes.[7-9] If left untreated, chronic ODP-M may lead to the disruption of outer retinal layers, atrophy of the retinal pigmented epithelium (RPE), and eventually vision loss, although spontaneous reabsorption of fluid has been reported to occur in as many as 25% of cases.[10,11]

Several papers have focused on preoperative characteristics in ODP-M to identify potential predictors of surgical outcome. The degree of retinal fluid, intrapapillary proliferation (IPP), and subretinal deposits have all been linked to disease severity and have been shown to have a detrimental impact on surgical prognosis.[12-14] However, because of the rarity of the disease, the evolution of OCT features in the course of ODP-M has still to be determined clearly.[15]

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Moreover, as far as we know, no previous investigation has focused on choroidal changes in ODP-M.

Starting from this assumption, we aimed to assess the possible involvement of the choroid in ODP-M, and how choroidal parameters may change before and after surgical treatment during a medium/long-term follow-up. Finally, these data were compared with those of fellow, healthy eyes.

MATERIALS AND METHODS

• **PARTICIPANTS:** This was a multicenter observational retrospective study on consecutive patients affected by ODP-M who underwent surgical treatment between 2013 and 2023 at the Instituto de Microcirugia Ocular, Barcelona, Spain, and at the Policlinico Universitario Agostino Gemelli, Rome, Italy. This research followed the tenets of the Declaration of Helsinki, and Institutional review board (IRB) approval was obtained from the Policlinico Universitario Agostino Gemelli – Catholic University of the Sacred Heart Institutional Ethics Committee. Written informed consent was obtained from all participants.

The main inclusion criterion was a diagnosis of monolateral ODP-M. Exclusion criteria were bilateral ODP-M, ODP-M previously operated upon, severe glaucoma, high myopia, active uveitis, visually impacting cataract, and severe systemic disease affecting ocular health. The fellow eye of each patient was taken as control. The presence of vitreoretinal interface disorders, any kind of maculopathy, severe glaucoma, or active uveitis in the fellow eye led to the exclusion of the case.

Overall, data regarding 84 eyes of 42 patients were retrieved from medical records.

• **EXAMINATIONS:** Patients' ophthalmological history was retrieved from medical records. At baseline, all patients underwent complete ophthalmic examination after pupil dilation. Examinations included best corrected visual acuity (BCVA), recorded as Snellen equivalent and then converted to logMAR, intraocular pressure (IOP) evaluation, and spectral domain (SD)–OCT evaluation, performed with the Cirrus 5000 high-definition (HD) OCT (Carl Zeiss) or the Mirante Scanning Laser Ophthalmoscope (SLO)/OCT (Nidek Co. Ltd).

Data regarding surgical treatment were accessed and gathered. Clinical and OCT characteristics were collected at baseline, at postoperative months 1, 6, 12, and 24, and at the most recent follow-up. All patients were followed for at least 12 months after surgery.

• **IMAGING ANALYSIS:** B-scans using the horizontal HD Raster 5-line (Cirrus 5000 HD) or the 12-mm Macula Cross (Nidek Mirante) were performed. ODP features were identified in color and red-free fundus photographs. ODP-M was diagnosed if fluid in the macular region was identified on OCT examination, and was classified as subretinal fluid (SRF) or intraretinal fluid (IRF) according to its location in the retinal layer. Built-in automatic calculation was used for the measurement of the central macular thickness (CMT).

Extracted B scan images were analyzed using ImageJ software (National Institutes of Health). Pixel to micrometer (μm) conversion was performed with the same software. All parameters were measured independently by 2 human graders. Choroidal thickness was evaluated manually in the ODP-M and the fellow eye at each follow-up: subfoveal choroidal thickness (SFCT), defined as the distance between the outer border of the hyper-reflective line defining the RPE and the choriosclera border, was calculated as the mean of the measurement below the foveal center and 2 measurements spaced 500 μm at the nasal and temporal sides; similarly, peripapillary choroidal thickness (PPCT), manually measured between the Bruch membrane hyperreflective line and the hyperreflective line of the inner surface of the sclera, was calculated as the mean of 3 measurements 250 μm apart from each other starting from the termination of the Bruch membrane in the temporal side of the optic disc (Supplemental Figure).

The presence of variations in the caliber of submacular choroidal vessels during the follow-up was assessed and qualitatively described. Moreover, abnormalities of the RPE layer, such as granularity or atrophy were assessed through the analysis of macular B scans. In a post hoc analysis, the cohort was divided into patients with "early" ODP-M eyes, characterized by a normal aspect of the RPE before surgery, and "advanced" ODP-M eyes, in which the RPE appeared partially or completely disrupted, thus suggesting a long-term fluid build-up in the macular area.

• **STATISTICAL ANALYSIS:** Statistical analysis was performed using GraphPad Prism Software, version 9.5 (GraphPad). The Shapiro–Wilk test was used to assess the normality of the sample. The Mann–Whitney *U* test was used with a 95% confidence interval to compare continuous variables. Two-way analysis of variance (ANOVA) with Dunnett correction was used to assess changes in OCT parameters during follow-ups, whereas the Sidak multiple comparisons test was used to assess differences between affected and fellow eyes at all timepoints and between the "early" and "late" ODP-M groups. Correlation analysis was performed using a Spearman coefficient. $P < .05$ was deemed statistically significant.

RESULTS

The study cohort included 42 eyes with ODP-M and 42 fellow healthy eyes. Mean age at diagnosis was 29.9 ± 18.7 years, and 54.7% of the patients were female. Mean follow-up was 38.5 ± 30.6 months (range, 12-108). Demographic

TABLE 1. Baseline Demographic and Clinical Characteristics of the ODP-M Cohort, Along With Surgery Type and OCT Features.

Cohort (n = 42)	Study Eye	Fellow Eye	P[a]
Age, y	29.9 ± 18.7		
Sex, male/female	19/23		
Follow-up, mo	38.5 ± 30.6		
Preoperative BCVA, logMAR	0.69 ± 0.50	0.0 ± 0.02	<.001
OCT Features			
CMT, μm	739.9 ± 233.5	245.4 ± 0.24.7	<.001
Intraretinal fluid (%)	36 (85.7%)	—	
Subretinal fluid (%)	16 (38.1%)	—	
SFCT, μm	386.8 ± 204.1	334.4 ± 72.2	.002
PPCT, μm	198.3 ± 47.8	171.7 ± 45.7	.14
Surgery Type			
PPV+hyaloid peeling	4 (9.5%)	—	
PPV+hyaloid peeling+peripapillary laser	14 (33.3%)	—	
PPV+ILM peeling	5 (11.9%)	—	
PPV+ILM peeling+peripapillary laser	8 (19.0%)	—	
PPV+scleral implant	1 (2.4%)	—	
PPV+HAM patch	10 (23.8%)	—	

BCVA = best-corrected visual acuity; CMT = central macular thickness; HAM = human amniotic membrane; ILM = internal limiting membrane; OCT = optical coherence tomography; ODP-M = optic disc pit maculopathy; PPCT = peripapillary choroidal thickness; PPV = pars plana vitrectomy; SFCT = subfoveal choroidal thickness.

[a]Mann–Whitney *U* testData are presented as mean ± SD.

and clinical characteristics of the patients are shown in Table 1.

Average BCVA of ODP-M eyes at baseline was 0.69 ± 0.50 logMAR. The OCT examination revealed a mean CMT of 739.9 ± 233.5 μm. Mean SFCT was 386.8 ± 88.9 μm in ODP-M eyes, significantly higher than in fellow eyes (334.4 ± 72.2 μm, $P = .002$), whereas mean PPCT showed no differences between affected and fellow eyes (192.6 ± 47.8 vs 181.2 ± 45.7 μm, $P = .46$). Correlation analysis highlighted a positive association between preoperative CMT and SFCT ($\rho = 0.403$, $P = .011$) (Figure 1).

All patients underwent surgical treatment with different techniques, as summarized in Table 1. Complete anatomical success, defined as persistently dry macula over time, was reached in 23 of 42 eyes (54.7%), whereas partial anatomical success, based on stable extrafoveal fluid not affecting vision, was reached in 9 of 42 (21.4%). In the remaining patients, 4 eyes (9.5%) developed vision-affecting recurrence of fluid within the first 24 postoperative months, whereas 6 eyes (14.3%) developed late recurrence, more than 24 months after first surgery.

Postoperatively, BCVA increased to 0.44 ± 0.29 logMAR at 6 months and 0.36 ± 0.33 logMAR at 12 months ($P = .03$ and $P = .008$ compared to baseline, respectively). Final best-corrected visual acuity (BCVA) was 0.36 ± 0.42 logMAR, which was significantly higher compared to preoperative values ($P = .01$).

• **CHOROIDAL THICKNESS EVOLUTION:** In 22 eyes, at the end of the surgical treatment, laser treatment was applied to the temporal peripapillary area. For this reason, these eyes were excluded from the analysis of PPCT.

Compared to preoperative values, SFCT already showed a significant reduction 1 month postoperatively (350.4 ± 82.0 μm, mean reduction 36.5 μm, $P = .009$) and remained below preoperative values throughout the follow-up. At final follow-up, SFCT was 307.4 ± 76.6 μm, showing a mean reduction of 79.4 μm from baseline ($P < .001$). Conversely PPCT did not show any changes when comparing preoperative to postoperative values ($P > .05$ at all follow-ups) (Figure 2).

As expected, either SFCT and PPCT of fellow eyes did not show significant variations over follow-ups. A summary of SFCT and PPCT changes throughout the study period is provided in Table 2.

Two-way ANOVA showed that eyes with ODP-M had significantly higher SFCT at baseline compared to fellow healthy eyes (mean difference 52.5 μm, 95% CI = 6.1-98.9 μm, $P = .017$). During postoperative follow-ups, no differences were reported between the 2 eyes at any timepoint (all $P > .05$). On the other hand, PPCT of ODP-M and fellow eyes did not differ significantly either at baseline (mean difference 11.4 μm, 95% CI = −15.8 to 38.5 μm, $P = .83$) or at any successive postoperative follow-up (all $P > .05$) (Figure 1).

• **CORRELATION WITH RETINAL FLUID LOCALIZATION:** At baseline, 37 of 42 eyes (88.1%) showed the presence of IRF, whereas 21 of 42 eyes showed SRF (50.0%). Sixteen eyes (38.1%) had combined SRF+IRF, whereas 21 eyes showed only IRF (50.0%) and 5 eyes only SRF (11.9%). The evolution of fluid localization during the study period is depicted in Figure 1.

Overall, we observed the presence of submacular dilated choroidal vessels in 9 of 42 eyes (21.4%). In 8 of 9 cases (89%), these dilated vessels were associated with the presence of SRF (odds ratio 12.3, CI = 1.8-142.2, $P = .008$), compared to only 1 eye showing dilated choroidal vessels in the absence of SRF. Postoperatively, the resolution of SRF determined the reduction in caliber of these vessels in all cases (Figure 3).

At baseline, eyes showing only SRF had nonsignificantly higher SFCT when compared either with eyes showing only IRF (446.4 ± 54.0 vs 375.4 ± 82.7 μm, mean difference 71.0 μm, 95% CI = −14.1 to 156.2, $P = .10$) or with eyes showing combined IRF+SRF (446.4 ± 54.0 vs 380.8 ± 102.4 μm, mean difference 65.6 μm, 95%

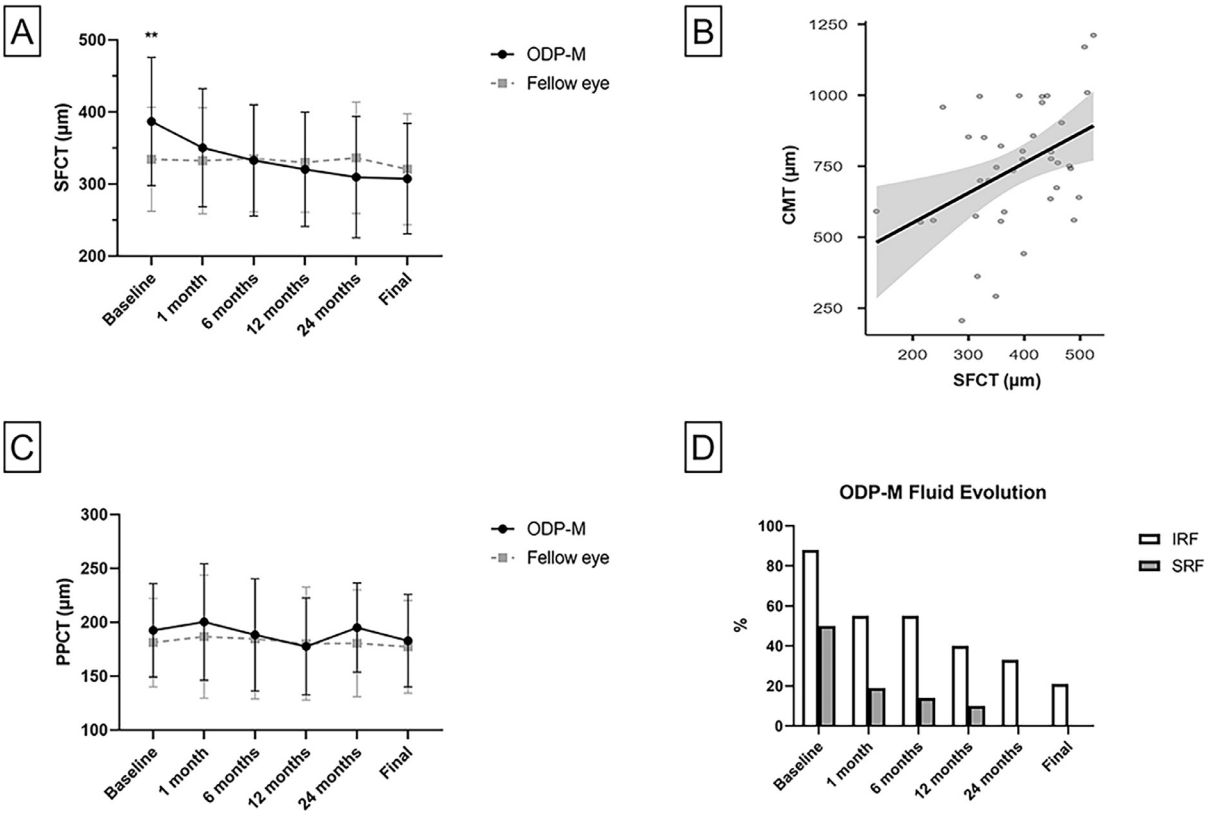

FIGURE 1. A. Line graph showing the comparison of subfoveal choroidal thickness (SFCT) between eyes affected by optic disc pit maculopathy (ODP-M) and fellow eyes during the study period. B. Correlation analysis between preoperative central macular thickness (CMT) and SFCT ($\rho = 0.403$, $P = .011$). C. Line graph comparing peripapillary choroidal thickness (PPCT) between ODP-M and fellow eyes, with no significant difference highlighted at any follow-up. D. Intraretinal fluid (IRF) and subretinal fluid (SRF) distribution among eyes with ODP-M throughout the study period.

TABLE 2. Evolution of choroidal thickness in the subfoveal and peripapillary area of study and fellow eyes.

	Study Eye	Fellow Eye	Mean Difference	95% CI	P[a]
SFCT, µm					
Baseline	386.8 ± 88.9	334.4 ± 72.2	52.47	6.061 to 98.87	.02
1 mo	350.4 ± 82.0	332.3 ± 73.6	18.06	–36.58 to 72.69	.74
6 mo	332.8 ± 77.3	335.4 ± 73.9	–2.600	–55.84 to 50.64	.99
12 mo	320.4 ± 79.4	330.2 ± 69.4	–9.752	–63.45 to 43.95	.89
24 mo	309.6 ± 84.3	336.4 ± 77.4	–26.75	–86.33 to 32.83	.54
Final	307.4 ± 76.6	320.6 ± 77.1	–13.12	–63.22 to 36.98	.61
PPCT, µm					
Baseline	192.6 ± 47.8	181.2 ± 45.7	11.39	–15.76 to 38.53	.84
1 mo	200.3 ± 54.0	186.7 ± 46.7	13.67	–64.91 to 92.25	.92
6 mo	188.3 ± 52.0	184.6 ± 44.9	3.733	–69.80 to 77.26	.99
12 mo	177.7 ± 44.9	180.2 ± 41.1	–2.533	–69.04 to 63.97	.97
24 mo	195.1 ± 48.8	180.5 ± 44.0	14.63	–55.58 to 84.83	.78
Final	182.9 ± 44.3	177.3 ± 43.1	5.667	–38.73 to 50.06	.95

ODP-M = optic disc pit maculopathy; PPCT = peripapillary choroidal thickness; SFCT = subfoveal choroidal thickness.
[a]Sidak multiple comparisons test.Data are presented as mean ± SD.

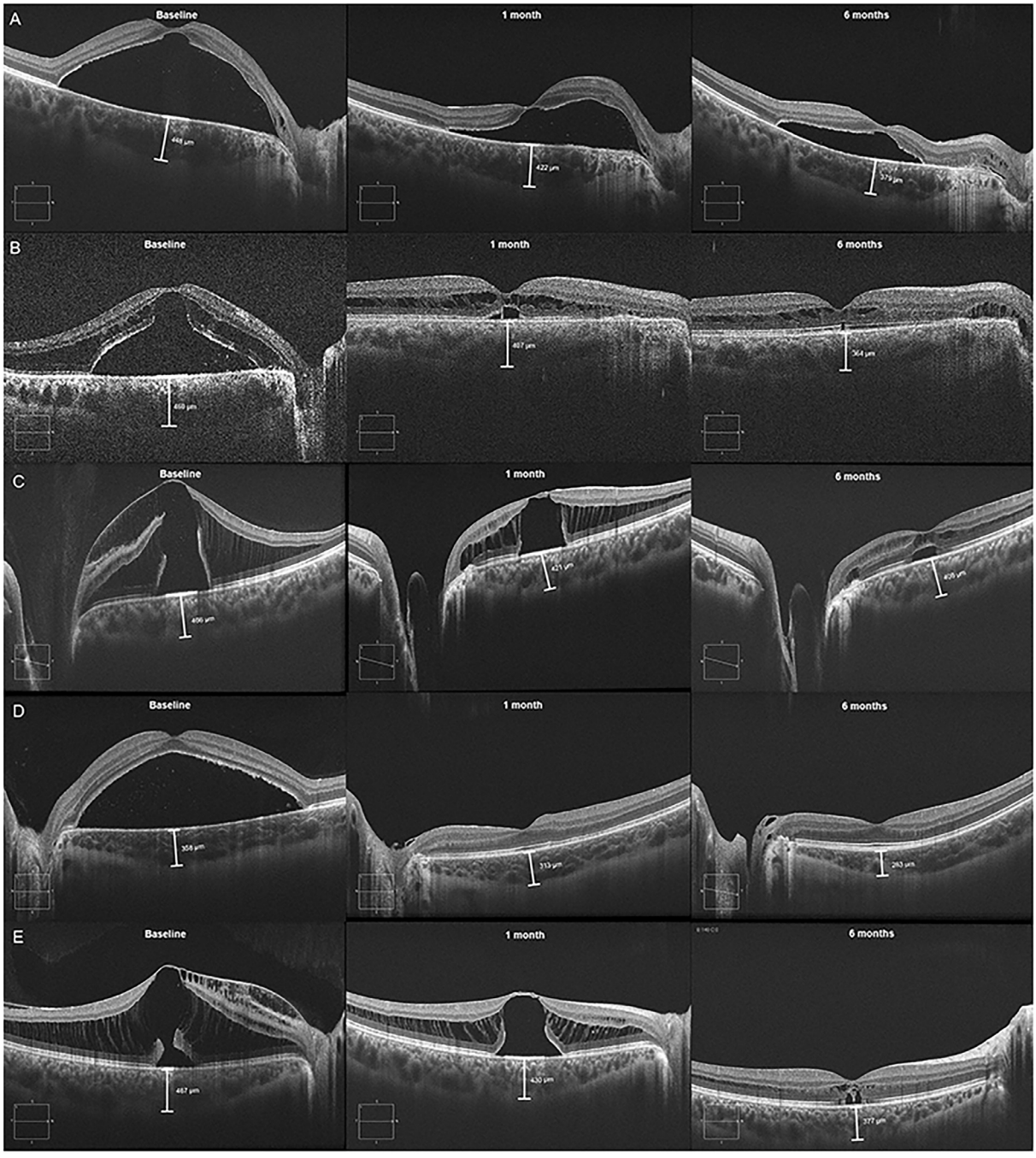

FIGURE 2. Collage of 5 patients (A-E) with optic disc pit maculopathy (ODP-M) showing the evolution of subfoveal choroidal thickness (SFCT) between preoperative and postoperative 1-month and 6-month follow-ups.

CI = −28.4 to 159.6, $P = .19$). Nevertheless, the statistical significance could have been affected by the small numbers of patients in the SRF subgroup. Moreover, no differences were reported among subgroups at any postoperative follow-up (all $P > .05$).

Changes in SFCT after surgical treatment were analyzed in the 3 subgroups. At the 1-month follow-up, SFCT was significantly reduced in the SRF subgroup (mean difference 42.8 μm, 95% CI = 7.4-78.2, $P = .02$) and also in the IRF subgroup (mean difference 29.1 μm, 95% CI = 6.5-51.7, $P = .01$) and in the IRF+SRF subgroup (mean difference 52.3 μm, 95% CI = 16.6 *P*87.9, $P = .005$). At the final follow-up, the IRF+SRF subgroup had experienced the highest reduction in SFCT from baseline (mean difference 112.6 μm, 95% CI = 66.5-158.7, $P = .0002$), followed by the SRF subgroup (mean difference 98.4 μm, 95% CI = 44.7-152.1, $P = .006$) and the IRF subgroup (mean difference 58.4 μm, 95% CI = 29.9-86.8, $P = .0001$).

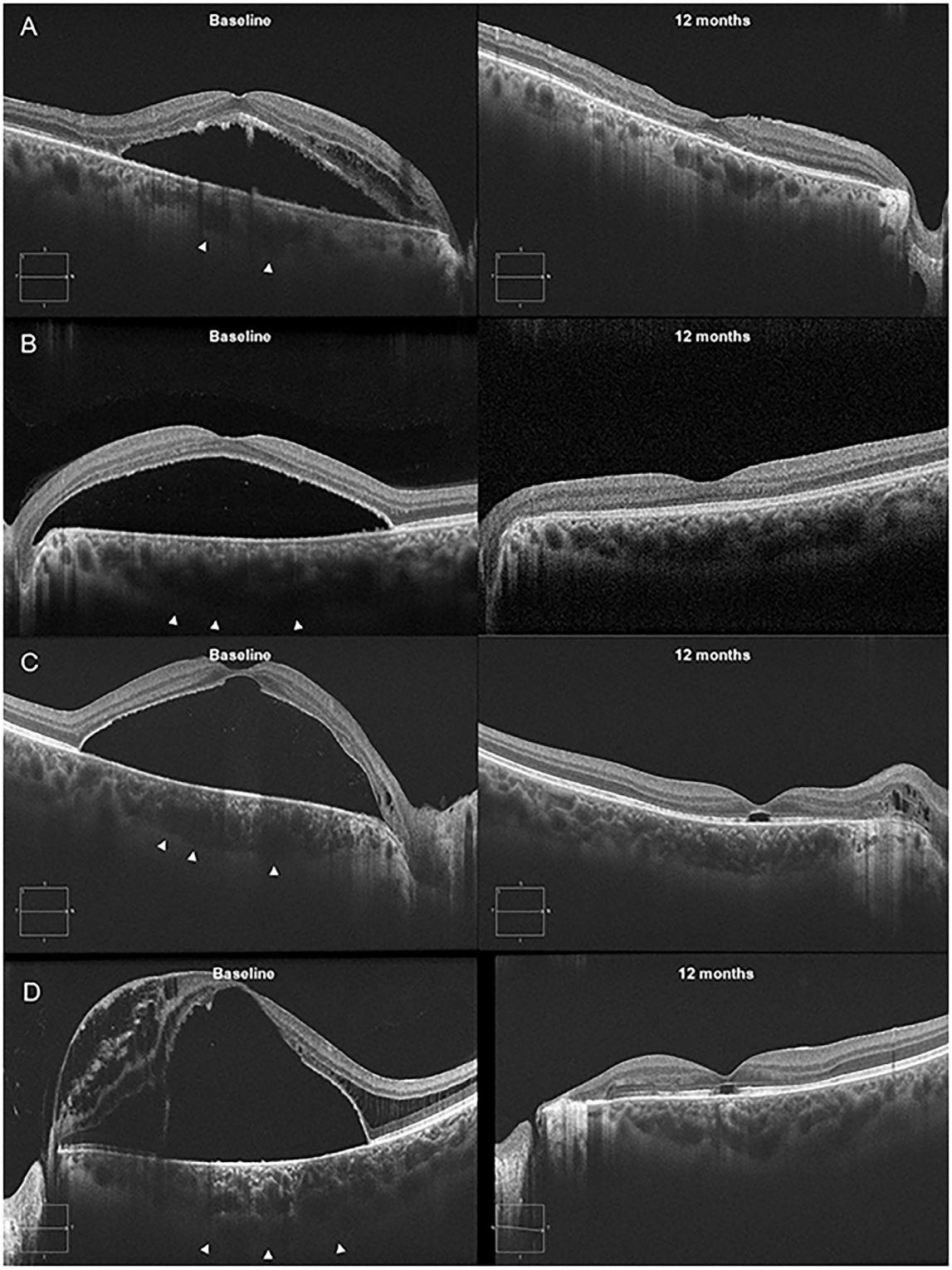

FIGURE 3. Collage of 4 eyes (A-D) with optic disc pit maculopathy (ODP-M) associated with subretinal fluid (SRF) showing the presence of dilated outer choroidal vessels (white arrowheads) in the subfoveal area, as we observed in 21.4% of eyes. Note that surgical treatment and resolution of SRF determined the reduction in caliber of outer choroidal vessels at 12-month follow-up.

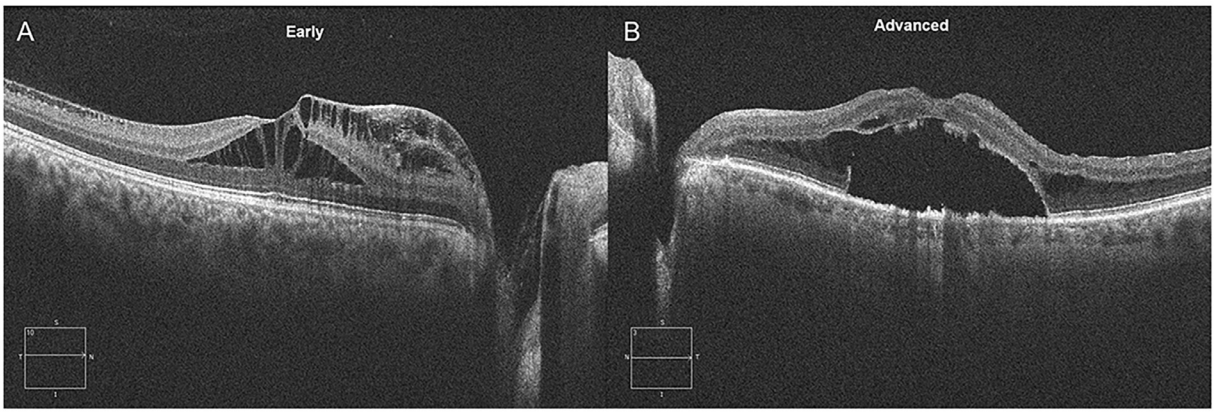

FIGURE 4. Samples of B scans of patients from the (A) "early" optic disc pit maculopathy (ODP-M) subgroup and the (B) "advanced" ODM-M subgroup, showing granularity and atrophy of the submacular retinal pigmented epithelium (RPE).

Graphical representation of SFCT evolution among subgroups in provided in Figure 4.

• **EARLY VS ADVANCED MACULOPATHY:** At presentation, we observed RPE abnormalities in 10 of 42 eyes (23.8%), which constituted the "advanced" ODP-M subgroup, compared with 32 of 42 eyes (76.2%) with normal RPE reflectivity ("early" ODP-M subgroup). Furthermore, preoperative age significantly correlated with the presence of RPE damage ($r = 0.6074$, $P = .0001$). Baseline BCVA was significantly lower in eyes from the advanced subgroup, compared to the early subgroup (1.12 ± 0.58 vs 0.57 ± 0.40 logMAR;, $P = .01$). However, both subgroups showed visual improvement after surgical treatment: in the advanced subgroup, BCVA was 0.38 ± 0.45 logMAR at 12 months ($P = .008$) and 0.58 ± 0.57 logMAR at the final follow-up ($P = .02$); in the early subgroup, BCVA was 0.36 ± 0.30 logMAR at 12 months ($P = .03$) and 0.29 ± 0.33 logMAR at the final follow-up ($P = .009$).

At baseline, eyes in the early subgroup had significantly higher SFCT values compared to the advanced subgroup (403.3 ± 76.7 vs 321.0 ± 108.9 μm, mean difference 82.3 μm, 95% CI = 2.1- 162.4, $P = .04$). Postoperatively, the difference between the 2 subgroups became nonsignificant (365.6 ± 75.2 vs 292.0 ± 87.1 μm at month 1, mean difference 73.6 μm, 95% CI = −19.3 to 166.5, $P = .21$) and remained so until the final follow-up (324.6 ± 71.4 vs 256.0 ± 71.6 μm, mean difference 68.6 μm, 95% CI = −9.4 to 146.6, $P = .12$) (Figure 4).

In early ODP-M, significant SFCT reduction was already reported at postoperative month 1 (mean difference 37.7 μm, 95% CI = 21.8-53.6, $P < .0001$). Conversely, no SFCT thinning was noted at month 1 in the advanced subgroup (mean difference 29.0 μm, 95% CI = −16.6 to 74.6, $P = .21$), whereas the difference from baseline became significant starting from the 12-month follow-up (mean difference 60.1 μm, 95% CI = 4.4-115.8, $P = .03$) (Figure 5).

DISCUSSION

To date, there is a relative paucity of reports in the literature analyzing the pathogenesis and long-term natural history of ODP-M. Moreover, data reporting the development of retinoschisis or serous detachment in 25% to 75% of patients with ODP are likely to be overestimated, because only patients with symptomatic ODP-M generally attend an outpatient clinic.[4,16] In this study, we have highlighted some aspects regarding choroidal involvement secondary to ODP-M. Specifically, we have shown that SFCT developed significant changes in association with the presence of ODP-M: preoperatively, SFCT showed higher values in ODP-M eyes when compared to fellow eyes (mean difference 52.5 μm). Moreover, greater preoperative fluid build-up in the macula, and hence greater CMT, correlated with thicker subfoveal choroid. Conversely, PPCT was stable among pre- and postoperative follow-ups, and remained always comparable to the values of fellow healthy eyes.

The origin of macular fluid in ODP-M is still debated.[2] According to histology, ODPs are caused by a dysplastic retinal herniation into the subarachnoid space by a faulty lamina cribrosa excavation, which causes a communication channel between the intraocular and subarachnoid spaces.[17] On the other hand, further research hypothesized that the vitreous may be the source of the fluid in ODPs.[16] Fluid localization in ODP-M was deeply analyzed in several OCT investigations, which revealed that the outer nuclear layer (ONL) was the most frequently affected, whereas approximately half of the eyes studied exhibited outer retinoschisis and concomitant subretinal fluid.[13,18] In particular, Roy et al suggested that fluid first gathers in the outer retinal stroma before moving toward the inner retinal and subretinal spaces.[19] Moreover, the presence of SRF significantly correlated with poor baseline BCVA.[11,20] Consistently with previous reports, in our research 88% of eyes

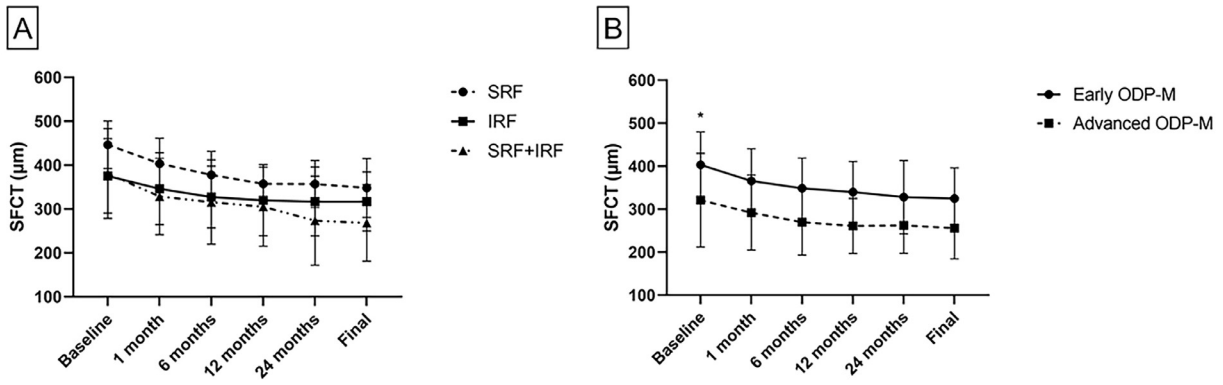

FIGURE 5. Line graph comparing eyes in the "early" versus "late" subgroup optic disc pit maculopathy (ODP-M) in terms of subfoveal choroidal thickness (SFCT), highlighting preoperative higher values in younger patients, whereas this significant difference is lost during follow-ups.

showed the presence of IRF, primarily localized in the ONL, whereas 50% of eyes showed SRF. In addition, we highlighted that fluid localization has a bearing on choroidal thickness and morphology. Macular scans highlighted the presence of dilated vessels in the outer choroid in 21.4% of eyes, and this finding was strongly correlated with the presence of SRF (odds ratio = 12.3). Regardless of fluid localization, surgical treatment was associated with choroidal thinning in all subgroups. However, SFCT reduction was more pronounced in eyes with SRF (−98.4 µm) or combined SRF+IRF (−112.6 µm), rather than eyes showing only IRF at baseline (−58.4 µm). Finally, the resolution of SRF build-up was associated with a reduction in caliber of the choroidal vessels in patients with dilated vessels at baseline.

Modifications of choroidal thickness have been demonstrated in several ocular conditions, with vascular hyperpermeability, inflammation, and RPE dysfunction all advocated as pathophysiologic triggers of choroidal remodeling. Although inflammatory mediators may increase vascular permeability and thicken the SFCT in uveitis,[21] in retinovascular disease, such as central retinal vein occlusion (CRVO), branch retinal vein occlusion (BRVO) and diabetic macular edema (DME), choroidal variations seemed a consequence of vascular endothelial growth factor (VEGF) expression, as demonstrated by SFCT variations after anti-VEGF therapy.[22,23] A combination of intraocular inflammation and choroidal hemodynamic mechanisms was also hypothesized at the basis of the higher SFCT and choroidal vascularity index (CVI) described in patients with retinitis pigmentosa (RP)–associated cystoid macular edema (CME), compared to eyes not developing CME. Moreover, the use of oral carbonic anidrase inhibitors (CAI), a well-known treatment for RP-associated CME, was able to reverse SFCT thickening.[24]

Conversely, the choroidal remodeling described in central serous chorioretinopathy (CSCR) most probably relies on the disruption of normal choroidal function, namely pachychoroid spectrum disease, in which the development of pachyvessels, choriocapillaris compression, venous overload choroidopathy, RPE dysfunction, and vascular hyperpermeability all play pathogenetic roles.[25,26] Although we observed dilated choroidal vessels reducing in caliber after surgical treatment in around 20% of eyes with ODP-M, particularly in those with SRF, the lack of multimodal imaging and quantitative analysis of vessel diameter made it unfeasible to define these as "pachyvessels." Furthermore, choroidal thickening and remodeling seemed to follow rather than precede the ODP-M occurrence, as demonstrated by the fact that surgical treatment induced a stable choroidal thinning over time, with SFCT values comparable to those of fellow healthy eyes. Choroidal changes appeared secondary to the development of the maculopathy and demonstrated reversibility in terms of both thickness and morphology, thus being probably an epi-phenomenon rather than a trigger for ODP-M. For instance, we reported a case in which ODP-M was not resolved 12 months after surgery and OCT highlighted a new SRF increase. Parallel to SRF build-up, the SFCT tended to re-increase and successively re-decreased after a second surgery (Figure 6). These findings suggested that the choroid acts as a regulator of retinal homeostasis and shows feedback in response to retinal changes.[27]

Physiologically, the RPE pump is recognized as the primary mechanism for retinal apposition and fluid reabsorption,[28] inducing a constant transepithelial water flow across RPE monolayers, mediated by aquaporin channels.[29] Recently, an increased SFCT was associated with the presence of persistent subretinal fluid (PSF) after rhegmatogenous retinal detachment (RRD) repair, suggesting the presence of RPE dysfunction and choroidal vascular hyperpermeability at the basis of a decreased rate of SRF reabsorption.[30] Similarly, Lim et al recently highlighted changes in choroidal structure, similar to those observed in pachychoroid spectrum disorders, in eyes with prolonged macula-off RRD associated with RPE damage.[31] In a similar way, the presence of IRF and SRF in ODP-M seemed to induce

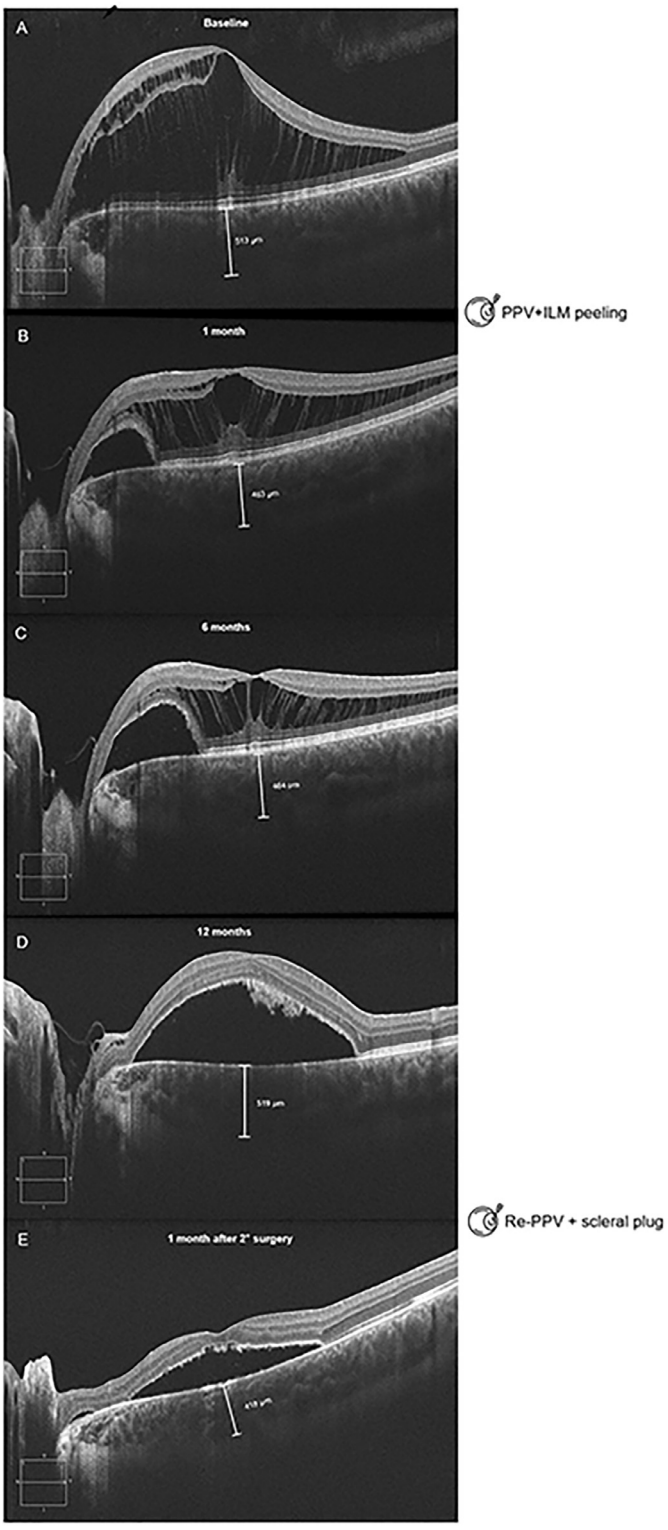

FIGURE 6. A. Collage of follow-ups of a 24-year-old man with optic disc pit maculopathy (ODP-M) with massive intraretinal fluid (IRF)/schisis. B, C. After the first surgery with pars plana vitrectomy (PPV) and internal limiting membrane (ILM) peeling, a partial resolution of the schisis was reported, along with a reduction in subfoveal choroidal thickness (SFCT), although some subretinal fluid (SRF) appeared. D. Twelve months after surgery, a relapse with significant SRF build-up was reported, in parallel with a re-increase in SFCT. A novel surgery with PPV and scleral plug implantation was performed. E. One month after the second surgery, the SRF had significantly reduced and likewise the SFCT, suggesting a plastic remodeling of the choroid in response to the presence of macular fluid.

an overload of RPE pump, constantly attempting to counteract the build-up of macular fluid, eventually leading to SFCT thickening.

Notably, RPE integrity appeared to be important in this homeostatic mechanism. In fact, patients with atrophic changes of the RPE (the "advanced" ODP-M group) had a lower baseline SFCT and a delayed response to surgical treatment, with a significant SFCT reduction from baseline only reported 12 months after surgery. Patients from the advanced subgroup were also older at presentation, suggesting that asymptomatic periods of ODP-M waxing and waning, or recurrent episodes of spontaneous resolution,[11] may have preceded the symptomatic clinical presentation and progressively damaged the RPE. Moreover, the impaired RPE function may have accounted for a slower response to surgical treatment in advanced cases, compared to the brisk response of eyes with "early" ODP-M, in which SFCT showed a rapid decrease after pit closure.

On the other hand, PPCT seemed not to be involved in this mechanism of plasticity. Despite being adjacent to the source of fluid passage, generally located at the temporal side of the optic nerve, the majority of ODP-M fluid accumulates in the foveal area. Because we did not report any changes in choroid thickness, we hypothesized that the lower fluid presence in the peripapillary retina determines a lower retino-choroidal flow that does not cause significant choroidal thickening. Moreover, the proximity to the optic nerve cup and the presence of a denser and more compact peripapillary sclera[32] may have hampered any changes on the stromal and vascular component of the choroid.

Of note, our study has several limitations, principally inherent to its retrospective design. In particular, the interval between ODP-M manifestations and symptoms was not retrievable, and thus the impact of time on RPE and choroidal changes could not be analyzed. Moreover, all patients promptly underwent operation after diagnosis, which did not allow us to evaluate the natural history of the reported retinal and choroidal abnormalities. Also, this research was based only on OCT analysis and lacked of multimodal imaging, such as indocyanine green angiography or OCT angiography, which could have been useful to further describe quantitative and qualitative choroidal modifications in this pathology. In particular, changes in choroidal vessels diameters could not be analyzed quantitatively, so further research is needed to assess whether variations in vessel caliber depended on physiological variability of the study population. Another limitation of the study is the small number of patients, although our cohort was comparable to other investigations in literature, and we were able to gather OCT data for a long postoperative period.

As a consequence of these limitations, generalization of the results should be made with caution. On the other hand, to our knowledge this is the first report to describe a certain degree of involvement of the choroid secondary to ODP-M, along with some novel insights regarding the natural history of the disease. Moreover, discovering the mechanisms of retino-choroidal balance in ODP-M may also offer useful clinical implications, eventually opening doors to novel treatment approaches. Further prospective studies with multimodal imaging are warranted to shed further light on this complex condition.

In conclusion, our study highlighted the presence of subfoveal choroidal swelling in patients with ODP-M scheduled for surgery. The surgical interruption of fluid transit through the ODP, causing the resolution of the maculopathy, made the choroid return to values comparable to those of fellow healthy eyes, with different timings in the case of early or advanced disease.

CREDIT AUTHORSHIP CONTRIBUTION STATEMENT

Matteo Mario Carlà: Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Francesco Boselli:** Writing – review & editing, Formal analysis, Data curation. **Federico Giannuzzi:** Writing – review & editing, Formal analysis, Data curation. **Emanuele Crincoli:** Software, Methodology. **Tomaso Caporossi:** Writing – review & editing, Visualization, Validation. **Carlos Mateo:** Validation, Supervision, Conceptualization. **Stanislao Rizzo:** Validation, Supervision, Conceptualization.

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