



Macular hole surgery follow-up with spectral domain-optical coherence tomography-guided facedown posturing

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Received: 29 June 2023 / Accepted: 24 March 2024
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Abstract

Purpose The main treatment for macular hole (MH) is pars plana vitrectomy, with or without internal limiting membrane (ILM) peeling, followed by gas tamponade and face-down positioning (FDP). This study aims to present the anatomical and visual outcomes following MH repair with optical coherence tomography (OCT)-guided FDP.

Methods Thirty-two patients who underwent surgery for idiopathic MH were enrolled. The requirement for the prone position was lifted for those with MH closure observed under gas on postoperative day one OCT. Patients with unclosed MHs were instructed to maintain FDP until the 3rd day. Best-corrected visual acuity at preoperative, postoperative 1st month, and the last visit, closure time post-surgery, duration of prone position, and surgical success rate were recorded.

Results Among the patients, 21 underwent phacovitrectomy + ILM peeling + gas tamponade, while 11 had vitrectomy + ILM peeling + gas tamponade. On postoperative day one, 28 out of 32 MHs closed, with 3 closures on day 3 and one on day 5. There were 18 stage two (56.3%), 13 stage three (40.6%) and 1 stage four (3.1%) MHs. The mean minimum MH diameter was 381.75 ± 68.07 (min 260–max 517) microns. All patients with MH closure time over postoperative day one had non-combined vitrectomy instead of phacovitrectomy. No late complications were observed.

Conclusions OCT-guided FDP approach yields excellent closure rates with no late complications and ensures good patient comfort.

Keywords Macular hole · Vitrectomy · Optical coherence tomography · Vitreoretinal surgery · Vitreoretinal interface

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Introduction

The main treatment for macular hole (MH) is pars plana vitrectomy with or without internal limiting membrane (ILM) peeling, and subsequent gas tamponade. The primary objective is to alleviate traction and prevent the accumulation of vitreous fluid beneath the retina through the hole [1]. ILM peeling is performed to remove residual vitreous cortex and stimulate glial repair [2, 3]. The rationale for using a gas tamponade is to isolate the macula from vitreous

fluid, providing a “scaffold” for Müller cells and fibrous astrocytes [1, 4]. To achieve this, the tamponade must have optimal surface contact with the macula, requiring careful patient positioning [5]. For macular holes, this coincides with face-down positioning (FDP) [6]. Hence, post-surgery, face-down posturing (FDP) used to be routinely advised. Among vitreoretinal surgeons, consensus regarding FDP after MH surgery is lacking, as it often depends on the surgeon’s preference. Current ophthalmological guidelines suggest that the duration of face-down positioning can vary from a few hours to two or more weeks [7]. However, for patients, adhering to postoperative face-down positioning is not only inconvenient but may also lead to complications, such as fellow-eye acute angle-closure glaucoma or pressure sores [8, 9]. Therefore, the necessity for FDP is still being questioned.

The first study to analyze closure rates without FDP was Tornambe et al., which had a 79% closure rate after the initial surgery without FDP [10]. Optical coherence tomography (OCT) studies have demonstrated retinal cyst flattening and initiation of MH closure by the postoperative day one in MHs smaller than 400 microns [11]. Muquit et al. [12] used Fourier domain OCT to demonstrate the sufficient gas-macula contact presence in an upright position on the first day after surgery.

In view of previous studies, the present study’s working hypothesis was that instead of advocating for a conventional one-week FDP or a radical no-FDP approach, a middle-ground solution would be a brief FDP duration guided by OCT imaging in cases of non-closure. In this study, we report the anatomical and visual outcomes after MH repair with OCT guided FDP followed until MH closure.

Methods

This prospective study was conducted in accordance with the Declaration of Helsinki and was approved by the institutional ethics committee (Baskent University ethics committee, KA 21/259). Informed consents were taken prior to the study.

Inclusion–exclusion criteria and examinations

All patients had undergone a complete preoperative ophthalmologic examination including measurement of the preoperative best-corrected visual acuity (logMAR), intraocular pressure (IOP) measurement, slit-lamp examination and fundus examination. SD-OCT images were specifically taken with Optovue AngioVue system due to its longer range of axial resolution (5 μ m) and scanning speed (70,000 A-scans per second) (Optovue, Inc., Fremont, CA). Both pre and postoperative OCT imaging were conducted with the patient in a sitting position since Optovue AngioVue system’s was able to detect the macula under gas tamponade.

The study enrolled patients with idiopathic macular holes (MHs) of all sizes, with the predominant symptom being a decline in visual acuity over the previous six months. Exclusion criteria included secondary MHs, previously operated retinal disorders and eyes with spherical equivalent of ± 6 diopters. All patients underwent a 25-gauge transconjunctival sutureless vitrectomy, internal limiting membrane (ILM) peeling utilizing a dual blue dye membrane, and gas tamponade (sulfur hexafluoride 20%). None of the macular holes were considered large enough to require an inverted flap for closure. If the patient was phakic, phacoemulsification and monofocal hydrophilic intraocular lens (Acrysof IQ, Alcon Laboratories, Inc.) implantation in the bag by using a cartridge introduction system without incision enlargement was performed in the same session. All procedures were performed by the same surgeon (G.Y). The same postoperative antibiotic (moxifloxacin 1.5%, 4 weeks) and anti-inflammatory (prednisolone acetate 1%, 6 weeks) eye drops were used for all patients.

FDP was initiated immediately after surgery. The positioning requirement was discontinued for patients with MH closure, as confirmed by shots taken under gas during the first postoperative day control using SD-OCT. Patients with unclosed MHs were scheduled for daily follow-up from the third day until closure was observed. Best-corrected visual acuity (BCVA) was recorded preoperatively, at the postoperative first month, and during the last visit, along with the time taken for MH closure after the surgery.

Results

The study comprised 14 males and 18 females, with 21 patients undergoing phacovitrectomy + ILM peeling + SF6 tamponade, while 11 patients underwent vitrectomy + ILM peeling + SF6 tamponade. The mean age was 66.19 ± 7.13 years (min 49–max 85). The mean preoperative IOP was 17.03 ± 3.04 mmHg. Mean preoperative spherical equivalent was 0.085 ± 1.57 diopters. The mean preoperative, postoperative first month and last visit visual acuities (Log-MAR) were 1.41 ± 1.25 , 0.44 ± 0.23 and 0.28 ± 0.19 respectively.

The distribution of macular hole stages included 18 stage two cases (56.3%), 13 stage three cases (40.6%), and 1 stage four case (3.1%). The mean minimum diameter of MHs was 381.75 ± 68.07 (min 260–max 517) microns. The mean MH closure time was 1.31 ± 0.89 days. Detailed patient characteristics are provided in Table 1.

28/32 (87.5%) MHs closed in postoperative day one. The mean minimum diameter of these MHs was 373.61 ± 66.83 (min 260 max 508) microns. Three MHs closed in postoperative day 3—all grade 3 MHs with the mean minimum diameter of 412.67 ± 4.93 (min 407 max 416) microns. One MH closed in day 5—grade 3 MH, minimum diameter 517 microns. (Figs. 1, 2 and 3).

Among the 32 patients, eight had co-morbidities, and all but one (case #25, closed on day 3) experienced MH closure on postoperative day one. All patients with MH closure time beyond postoperative day one had undergone non-combined vitrectomy instead of phacovitrectomy. No late complications were observed.

Discussion

This current study has found that an approach of face-down positioning followed by Optical Coherence Tomography-guided modification is a safe and effective postoperative plan with a good macular hole closure rate.

The photoreceptor layer, spanning both sides of the fovea, requires reconnection at the torn edges of the macular hole by Muller cell sealing for anatomical closure [13]. In experimental retinal holes, this was

shown to take 7 days—hence the advice of FDP after MH surgery [14].

About the necessity of face-down positioning, Simcock et al. [15] published the first comparative study. Twenty patients who underwent combined phacovitrectomy with ILM peeling were instructed not to lie face-up for 10 days, but they were not given face-down posturing instructions. The closure rates of these MHs were compared with historical controls that were given FDP after same procedure. Eighteen out of the 20 non-postured eyes exhibited MH closure after 6 months, compared to 11 out of 13 in the postured group. This lack of statistical difference between the two groups suggested comparable outcomes in terms of MH closure rates and they argued that combined phacovitrectomy allowed for sufficient gas tamponade presence to make face-down positioning irrelevant for the healing process. The first prospective study was published by Tranos et al. [16] For their first group (n = 16), patients were instructed not to lie supinely after surgery without initiating face-down positioning. A comparison was made with 25 patients who underwent FDP. The MHs in their study were predominantly stage 2 and 3, with six patients having stage 4 MHs. They observed no significant differences in visual outcomes or primary anatomical closure between the postured and non-postured groups. Their study had both phacovitrectomy and vitrectomy patients, with the non-postured vitrectomy group showing a higher incidence of posterior capsular cataracts four months postoperatively. They concluded that FDP is not necessary for MH closure but combined surgery may be recommended if no FDP will be given. Pasu et al. [17] evaluated macular holes larger than 400 microns in size. They divided patients into two groups: those undergoing face-down positioning and those in a face-forward position. The results indicated no significant difference between the groups in terms of MH closure, but the FDP group showed better visual acuity. It's noteworthy that the study included phakic eyes with face-forward postures, suggesting a potential protective effect of FDP on the lens against gas tamponade. It is routine practice in our clinic to perform combined phacovitrectomy for phakic patients with vitreoretinal interface disorders for exactly this reason, and therefore all patients were either already pseudophakic or had combined surgery. The first multicenter study was published by Guillaubey et al. [18] comparing

Table 1 Patient characteristics

Case No	Age	Pre-operative Visual Acuity (LogMAR)	Phaco-vitrectomy (PV)/Vitrectomy (V)	1-month Visual Acuity (Log-MAR)	Final Visual Acuity (Log-MAR)	MH Closure-time (day)	Follow-up Time (Months)	MH stage	MH minimum diameter (micron)*	Comorbidity
1	64	1.0	PV	0.4	0.4	1	5	4	508	-
2	63	0.5	V	0.5	0.2	1	6	2	390	-
3	68	1.3	PV	0.5	0.3	1	23	2	348	HT
4	63	1.0	PV	0.2	0.2	1	7	2	366	DM
5	54	1.3	V	0.2	0.1	1	24	3	440	-
6	74	0.7	PV	1.0	0.0	1	13	3	410	-
7	70	3.0	V	0.3	0.2	5	28	3	517	-
8	75	1.0	V	0.5	0.5	1	22	2	320	-
9	66	0.7	PV	0.3	0.1	1	10	2	350	-
10	67	0.7	PV	0.2	0.5	1	14	2	336	-
11	55	1.0	PV	0.4	0.2	1	4	3	462	-
12	59	2	PV	0.3	0.0	1	25	3	405	-
13	62	0.7	V	0.7	0.7	3	6	3	416	-
14	73	3.0	PV	0.5	0.4	1	25	2	310	-
15	75	0.8	PV	0.5	0.4	1	5	3	444	-
16	65	0.8	PV	0.3	0.1	1	20	2	300	HT,DM, CKD
17	69	3.0	V	0.5	0.5	1	4	2	282	-
18	65	0.8	V	0.7	0.5	1	6	2	375	-
19	71	1.0	PV	0.7	0.7	1	10	2	336	HT
20	63	1.0	V	0.5	0.5	1	5	2	313	-
21	67	1.0	V	0.7	0.4	1	4	2	390	-
22	73	1.0	PV	0.4	0.4	1	7	2	374	HT
23	70	3.0	V	0.7	0.2	3	28	3	407	-
24	66	1.0	PV	0.2	0.2	1	10	3	402	-
25	69	1.0	V	0.2	0.1	3	8	3	415	HT
26	85	1.0	PV	0.7	0.4	1	9	2	260	DM
27	63	0.7	PV	0.2	0.2	1	7	3	485	-
28	71	1.3	PV	0.2	0.2	1	9	2	278	PAAG
29	49	1.3	PV	1.0	0.0	1	10	2	368	-
30	67	0.7	PV	0.2	0.2	1	12	3	485	-
31	56	1	PV	0.4	0.1	1	12	2	307	-

Table 1 (continued)

Case No	Age	Pre-operative Visual Acuity (LogMAR)	Phaco-vitrectomy (PV)/Vitrectomy (V)	1-month Visual Acuity (LogMAR)	Final Visual Acuity (LogMAR)	MH Closure-time (day)	Follow-up Time (Months)	MH stage	MH minimum diameter (micron)*	Comorbidity
32	61	0.7	PV	0.1	0.1	1	12	3	417	-

*Distance between the edges of the torn and elevated photoreceptor layer

HT Hypertension, DM Diabetes mellitus, CKD Chronic kidney disease, PAAG Primary open angle glaucoma

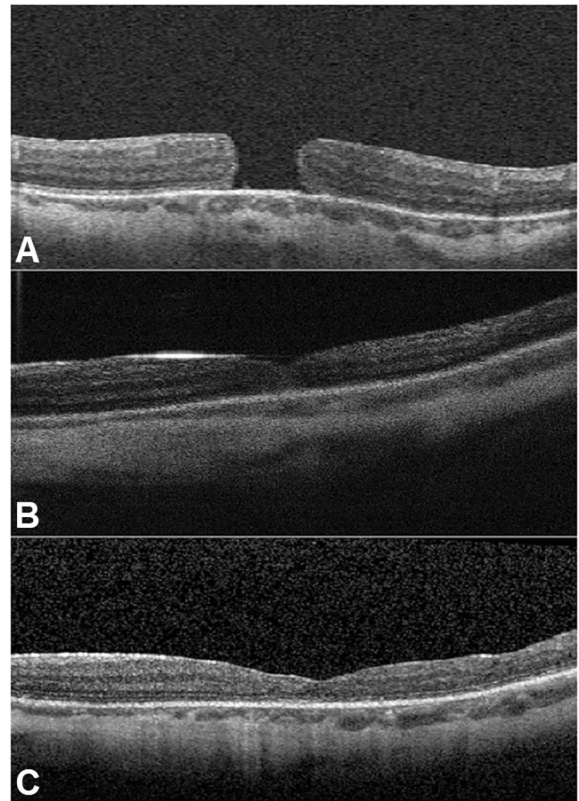


Fig. 1 A Preoperative SD-OCT image of case#1 B Macular hole closure in postoperative day one C Postoperative month one image

face-down positioning with seated positioning in 150 eyes. The study revealed that patients with MHs exceeding 400 microns had worse anatomical outcomes if they did not undergo FDP. Consequently, the authors recommended FDP specifically for larger holes. Tadayani et al. [19] in their multicenter study, agreed with this recommendation and suggested that FDP might not be necessary for smaller holes. In another study by Krohn et al. [20] a comparison between 3-day and 7-day FDP showed no significant differences in visual or anatomical outcomes. In our study, every macular hole that took more than one day to close was larger than 400 microns. Yet, 10 out of the 14 MHs exceeding 400 microns exhibited closure on day one, as observed through optical coherence tomography with face-down positioning. Based on these findings, we believe that OCT guidance is instrumental in determining the optimal cessation point for FDP, allowing for a more tailored approach

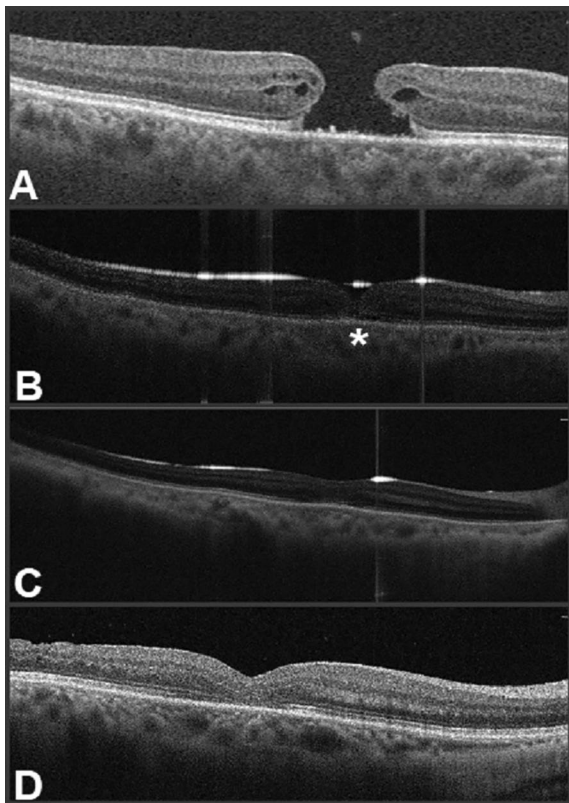


Fig. 2 A Preoperative SD-OCT image of case#7 B Postoperative day one image showing non-closure of the hole (*) C Postoperative day five image showing macular hole closure D Postoperative month one image

and avoiding the need for prolonged positioning in postoperative care.

In a prospective multicenter study involving 203 eyes, patients were instructed to refrain from upward gaze and a supine sleeping position for 3–5 days [21]. 202 out of 203 MHs closed successfully with short-term non-supine positioning without the need for FDP. Alberti et al. [22] conducted a comparative analysis between FDP and non-supine positioning (avoiding upward gaze and supine sleeping), revealing similar success rates in both groups. In a study by Zhang et al. [23] a comparison between 40 eyes undergoing FDP and 40 eyes in a non-supine position demonstrated non-inferiority between the two groups. Additionally, Elborgy et al. [24] retrospective study, focusing on chronic MHs with a mean duration of 5.0 ± 6.9 years, achieved closure in 17 out of 18 eyes using face-forward positioning. It's noteworthy that FDP itself may not be strictly necessary based

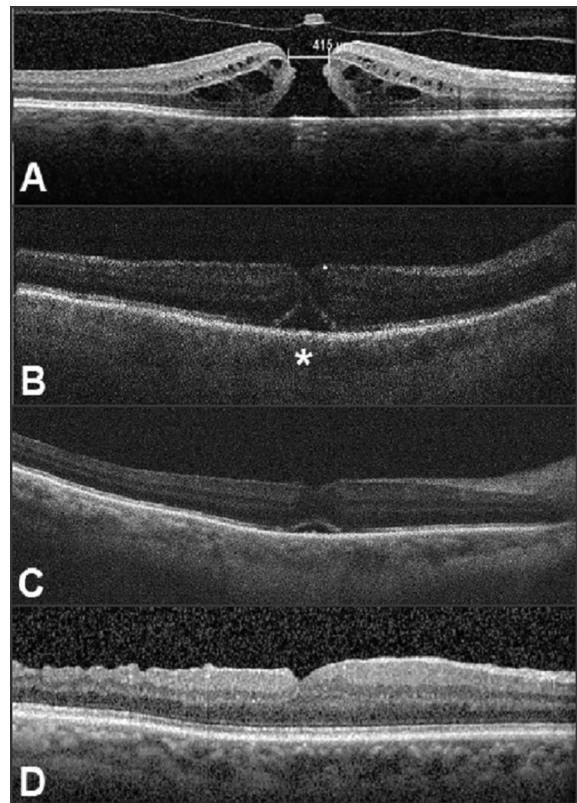


Fig. 3 A Preoperative SD-OCT image of case#25 with minimum diameter shown B Postoperative day one image showing non-closure of the hole (*) C Postoperative day three image showing macular hole closure D Postoperative month one image

on these findings. However, patients in these studies were still given specific positioning instructions, with a preference towards face-forward postures. Considering that experimental retinal holes take 7 days to close, this study's patient group was advised to assume immediate FDP after the surgery, and FDP was only discontinued once full MH closure was confirmed through optical coherence tomography. This approach has an individualized strategy, tailoring postoperative positioning based on monitoring of MH closure progress.

OCT studies incorporating advice on facedown positioning were also conducted using both Swept-Source OCTs (SS-OCT) and Spectral/Fourier-Domain OCTs (SD-OCT). In 2007, Eckardt et al. [25] employed SD-OCT in prone positioning at 24 h, 48 h, and the third day postoperatively, revealing a 54% closure of macular holes on the first day. In 2009,

Masuyama et al. performed standard SD-OCT three hours after surgery and managed to get images in 3 of the 5 eyes. Their study showed MH closure in 10 out of 13 eyes on the first day, similar to the present study, which demonstrated an 87.5% closure rate on the postoperative first day with immediate FDP. Masuyama et al. [26] also discontinued FDP upon witnessing MH closure with OCT and suggested extending the FDP only if no evidence of closure is observed. Their follow-up routine was identical to the present study with similar results, supporting the value of OCT-guided positioning. Yamashita et al. (n=107) divided their study participants into two groups. Group A1 underwent immediate FDP after surgery, Group A2 received FDP only if MH closure was not observed by postoperative day 2, and Group B followed conventional 7-day FDP. [27] SD-OCT examination was performed at six hours postoperatively. MH closure was observed in 60% on the morning of the postoperative day one, and found no significant difference between immediate posturing and posturing if needed. Closure rates in these groups were comparable to the traditional 7-day FDP group. They argued that immediate posturing is not imperative, and posturing can be initiated when deemed necessary based on SD-OCT. However, we argue that their approach, given a 60% closure on postoperative day one followed by FDP, may pose a minimal risk compared to immediate positioning. In Shah et al.'s study (n=32), patients were promptly subjected to FDP following surgery, with SD-OCT conducted on the first day. Even after MH closure was confirmed within 24 h, an additional two days of FDP were maintained. The rationale behind this decision was that imaging on postoperative day one might not reliably predict closure rates in the subsequent postoperative period when the gas has dissipated. [28] In contrast, the present study, which also involved 32 patients, discontinued FDP upon MH closure in OCT, even on the first day, without any late complications observed in the patient cohort. Kikushima et al. employed SS-OCT in their study, assessing eyes that underwent ILM peeling, gas tamponade, and FDP just 20 min postoperatively. Results showed MH closures as early as day 0 (1 eye) and day 1 (10 eyes), primarily observed in smaller-sized MHs. The latest closure was observed on day seven. Upon OCT confirmation of closure, FDP was discontinued, and non-supine positions were permitted [29]. Although SS-OCT's greater

penetration depth may offer increased value compared to SD-OCT, considering the majority of closures occurred on day one in their study, we posit that earlier than day one OCT imaging may not be strictly necessary.

This study had limitations, such as variable MH sizes and a limited number of eyes. Nevertheless, it demonstrated that a well-regulated OCT-guided face-down positioning approach yields excellent closure rates with no late complications and ensures good patient comfort, thereby contributing to the reliability of prior OCT-guided studies. Future investigations could explore diverse positioning approaches guided by OCT.

Acknowledgements None.

Author contributions Author contribution: RAK, SAB (Planning, Acquisition and preparation of data). ZEE (writing the main manuscript, figure preparation), IA (Acquisition of data, Preparation), GY (Acquisition of data, Supervision, review). The manuscript has been read and approved by all the authors.

Funding The authors declare that no funds, grants, or other support were received during the preparation of this manuscript.

Declarations

Conflict of interest The authors have no relevant financial or non-financial interests to disclose.

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