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OPTICAL COHERENCE TOMOGRAPHY–GUIDED FACEDOWN POSITIONING FOR MACULAR HOLE SURGERY

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Abstract

Purpose—To use spectral domain optical coherence tomography–guided duration of facedown positioning to study anatomical macular hole closure rates.

Methods—Retrospective review of patients with macular holes undergoing 23-gauge pars plana vitrectomy and intraocular gas tamponade. Spectral domain optical coherence tomography imaging was done on postoperative Day 1. Patients remained facedown for 2 more days if the macular hole was closed or 6 more days facedown if the macular hole was open or indeterminate.

Results—There were 8 Stage 2, 12 Stage 3, and 12 Stage 4 macular holes. On postoperative Day 1, 24 holes were closed by spectral domain optical coherence tomography and instructed to remain facedown for two more days. Twenty-three of 24 holes remained closed during the postoperative period. Eight holes were open or indeterminate on postoperative Day 1 and remained facedown for 6 more days. Six of 8 holes (75%) were closed at their last follow-up. The overall closure rate was 29/32 (90.6%). Average follow-up was 334 days.

Conclusion—Confirming early closure of macular holes with spectral domain optical coherence tomography imaging can serve as an important guide to significantly shorten the duration of prone positioning while maintaining high closure rates.

Keywords

facedown positioning; macular hole surgery; optical coherence tomography; prone positioning; spectral domain optical coherence tomography; vitrectomy

Before the early 1990s, macular holes were considered nontreatable. In their original report, Kelly and Wendel¹ achieved a 58% anatomical macular hole closure rate with 1-week duration of facedown positioning.² Modern macular hole treatment has evolved to include small-gauge pars plana vitrectomy with or without internal limiting membrane (ILM) peeling and placement of intraocular air or gas tamponade with single surgery anatomical closure rates of 90% or greater. Despite these improvements, controversy remains over the duration of facedown positioning. Prolonged facedown posturing is not only an inconvenience but also imposes physical, mental, and medical risks that can be a major burden for patients who are elderly. Although many have recommended <1 week or even no posturing,^{3–9} some surgeons continue to use up to 1 week of posturing facedown arbitrarily. It may be beneficial to be able to use spectral domain optical coherence tomography (SD-OCT) to guide the decision-making process.

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Recent studies demonstrate the ability of optical coherence tomography (OCT) to successfully image the macula through gas and to guide the duration of positioning.^{10–12} Spectral domain optical coherence tomography may be better than time-domain optical coherence tomography by providing improved macular coverage and resolution and minimizing skip areas in localizing the fovea after macular hole surgery with intraocular tamponade.

We conducted a retrospective review of patients whose postoperative management was directed by the status of macular hole closure by SD-OCT on postoperative Day 1.

Materials and Methods

This is a retrospective study of patients whose postoperative management was directed by postoperative Day 1 SD-OCT imaging. This study was approved by the Institutional Review Board/Ethics Committee of the Tufts Medical Center and is adherent to the tenets of the Declaration of Helsinki. Inclusion criteria included patients with any Stage 2, 3, or 4 macular holes willing and able to provide informed consent to enter the trial. Exclusion criteria included inability to provide informed consent or inability to position facedown for up to 1 week.

Thirty-two eyes of 32 patients with Stage 2, 3, or 4 macular holes based on clinical staging who underwent macular hole surgery and SD-OCT on postoperative Day 1 to guide duration of facedown positioning were identified. These patients were seen and treated at the retina service of the New England Eye Center, Tufts Medical Center, Boston, MA, or Ophthalmic Consultants of Boston, Boston, MA, between August 2009 and August 2010.

Patients underwent routine preoperative comprehensive ophthalmic examination and testing for macular hole evaluation. Surgical technique consisted of 23-gauge, 3-port pars plana vitrectomy and full intraocular gas endotamponade. The intraoperative use of intravitreal triamcinolone acetonide, indocyanine green (ICG) dye, both, or no stain was up to the discretion of each operating surgeon. Intraocular gas choice and concentration were also at the surgeon's discretion. After surgery, patients were instructed to remain facedown until their follow-up visit on postoperative Day 1.

The macula was scanned using the spectral domain Cirrus high-definition optical coherence tomography (software version 4.5; Carl Zeiss Meditec, Dublin, CA) retinal scanner preoperatively, on postoperative Day 1 through the gas bubble, and then again at postoperative Week 1, Month 1, and Month 3. High-definition 5- and 1-line raster scans and 3-dimensional 512 × 128 macular cube scans were all used on each visit and analyzed by the operating retinal surgeon. Scanning was performed by a trained OCT technician who optimized the scans through adjustment of the Z-focus and positioning of the scan pattern, particularly on postoperative Day 1 when imaging through the fully gas-filled eye was the most challenging.

Determination of hole closure on postoperative Day 1 guided the recommendation of duration of facedown positioning. If the macular hole was closed by SD-OCT, then the patient was advised to assume facedown positioning for a total of 3 days from the day of surgery. If the hole was open or if the status of the hole could not be confirmed, then the patient was advised to assume the facedown position for a total of 7 days from the day of surgery. Patients were then followed for routine postoperative visits on Week 1, Month 1, and between Months 3 and 6.

For purposes of data analysis, completing a postoperative period of 3 months without hole recurrence was considered an anatomical success. Successful anatomical hole closure was

considered when the hole was closed on SD-OCT when the gas bubble was <50%. Failure to anatomically close the hole was considered when the hole was open on SD-OCT when the gas bubble was <50%. If a hole failed to close or reopened within the postoperative period, then the recurrent hole was treated at the discretion of each physician. Relevant data were collected for each of the postoperative visits, including the most recent follow-up interval available.

Results

Patient characteristics are summarized in Table 1. Of the 32 patients enrolled in the study, the average age was 66 years (range, 40–90 years), 20 were women, and 12 were men. Eighteen were right eyes and 14 were left eyes. Nineteen were phakic and 13 were pseudophakic. Eight holes were Stage 2, 12 Stage 3, and 12 Stage 4. Four holes were preoperatively recurrent, which were referred to the practice for a second opinion. Twelve eyes underwent surgery without the use of a stain, triamcinolone acetonide was used in 4 eyes, ICG in 18 eyes, and both triamcinolone acetonide and ICG in 2 eyes. Only 2 eyes (6.2%) received C₃F₈ 15% gas with the rest (30 eyes, 93.8%) receiving SF₆ gas (20–30%). The follow-up interval ranged from 14 days to 748 days with an average of 334 days and median of 312 days.

The study algorithm is shown in Figure 1. Of the total 32 eyes with macular holes, 24 (75.0%) were determined to be closed by SD-OCT on postoperative Day 1 (Figure 2). These patients were instructed to remain facedown for 2 more days (representative example, Figure 4). The remaining 8 eyes (25.0%) were either indeterminate or open by SD-OCT and instructed to remain facedown for 6 additional days (representative example, Figure 5).

Of the 24 eyes that were closed by SD-OCT on postoperative Day 1 and assumed 2 more days facedown, 23 (95.8%) remained closed throughout the defined postoperative period; of these, 8 holes were preoperatively small (<400 μ m) and 16 holes were preoperatively large (>400 μ m). Patient 32 had undergone 23-gauge pars plana vitrectomy, ICG-assisted complete macular ILM peeling, and SF₆ gas endotamponade. She was advised to assume 3 days facedown as closure was determined on SD-OCT by the operating surgeon on the first postoperative day. She was found to have an open macular hole at the Week 1 postoperative visit. At the Week 1 visit, additional 100% SF₆ gas (0.4 cc) was injected into the vitreous cavity. The patient was advised to assume facedown for a full additional week. At subsequent follow-up visits, the hole was closed without late recurrence or need for an additional surgery (Figure 6). One additional patient (25) developed a recurrent macular hole at postoperative Month 4 because of recurrent epiretinal membrane (ERM) formation and successfully closed with repeat vitrectomy with ERM and ILM peeling (Figure 3 and representative example, Figure 5).

Of the 8 macular holes that were either indeterminate or open by SD-OCT on the first postoperative day and assumed a total of 7 days facedown, 6 holes were closed at subsequent follow-up visits. Each of these holes was preoperatively large (>400 μ m).

The closure rate using the algorithm depicted in Figure 1 was 90.6% (29/32). We were able to successfully close 93.8% (30/32) with 1 or more interventions within the 3-month postoperative period. The 2 holes that ultimately did not close were Stage 4 and present for more than 3 years by history; additional surgery was not recommended. Preoperative and final visual acuity data are shown in Table 1.

Discussion

Multiple factors have been considered for the success of macular hole surgery in the published literature. These include ILM peeling,^{13–18} short- and long-acting endotamponade agents,^{19–23} simultaneous cataract extraction,^{24–26} and the necessity and/or duration of facedown positioning. The one factor that continues to impact a patient's physical, mental, and medical well-being is the restriction of facedown positioning. The present study demonstrates how the ability to obtain an image can be used to significantly shorten the duration of facedown positioning to at most 3 days and still maintain anatomical closure rates above 90%.

Some have advocated reduced or even no facedown positioning instead of the often accepted 1 week recommendation.^{3–5,7,9,10,12,19,27,28} Although OCT has become a vital tool in the evaluation and management of macular disease, its utility with macular hole surgery in the immediate postoperative period was originally limited by the interfering reflections of the gas bubble. Recent studies indicate the ability to show early macular hole closure on OCT through a gas bubble,^{10–12} and data from our group indicate the consistent ability to image the macula through an intraocular gas bubble with a variety of SD-OCT machines, some more successful than others.²⁹

Microplasmin studies suggest that simple release of vitreofoveal adhesion can result in macular hole closure without the need for surgical intervention and face-down positioning. This benefit was noted in 10 patients (18.5%) with macular holes of the 54 total patients with macular holes enrolled in the Phase II study, suggesting benefit for a very limited number of patients.³⁰

Several inferences can be made from the data in this study. First, all the preoperatively small holes (<400 μm) could be imaged on postoperative Day one and all required only 3 days facedown. Second, all the holes that remained open or indeterminate and required 7 days facedown were preoperatively large (>400 μm). These findings suggest that small holes probably require minimal or no facedown positioning and large holes may require extended facedown positioning.

Patient 32 is an interesting case study of a myopic, large, macular hole in a young patient. She underwent uncomplicated 23-gauge pars plana vitrectomy/ICG dye/ILM peeling and SF₆ gas. She was advised to undergo 3 days facedown after the SD-OCT imaging through the gas bubble had the appearance that the hole was closed on postoperative Day 1 (Figure 6A). The hole was open by SD-OCT at the 1-week postoperative visit (Figure 6B, intraocular SF₆ gas <50%). There are several possibilities. First, it is possible the hole was never really closed and that clinicians cannot fully depend on the postoperative Day 1 OCT to know if the hole will be closed at 1 week. It is also possible that the hole was closed on postoperative Day 1 but reopened very early. The hole subsequently closed with supplemental intraocular gas and extended facedown positioning alone. The role of this buoyant force has been debated.³¹ Berger and Brucker³¹ have suggested the buoyant force may be more important in cases where the tangential tractional forces from an epiretinal membrane are not relieved. In this particular case, the hole was open despite definitive traction release with ICG assisted the ILM peeling. Therefore, this suggests that buoyancy of the bubble may play a role in macular hole closure, whether it be from a direct pressure effect or to simply isolate the hole from the liquid vitreous.³¹ Large macular holes and possibly high myopia and young age may be risk factors where prolonged positioning may help facilitate long-term closure.

Patient 25 completed 3 days of facedown positioning with closure through at least 3 months with excellent improvement in visual acuity. He had a late reopening after 4 months

attributed to a recurrent ERM. The ILM was not peeled at the initial surgery but was subsequently removed with a second vitrectomy using ICG with successful repeat long-term macular hole closure. In this case, reopening was not attributed to the duration of facedown positioning given the new ERM and long interval after the initial surgery, thereby counting this as a complete success for purposes of the data analysis. Also, leaving the ILM intact with the initial surgery possibly increased the risk for recurrent ERM and late macular hole reopening.

Despite the high success rates reported with our study algorithm, several limitations exist. First, this is a retrospective study and the sample size is small. In addition, the 3-day shortened duration of facedown positioning was arbitrarily selected. It is feasible that even shorter or no facedown positioning could be used with SD-OCT imaging with equally successful results. Last, these results were compiled from 7 surgeons who participated in the study. Certainly, variations in technique including the use of ICG and/or ILM peeling may have an impact on anatomical macular hole success rates, although our study's overall rate is on par with the published literature.

In conclusion, SD-OCT is an excellent tool to guide the recommendation of the duration of facedown positioning by vitreoretinal surgeons. It must also be emphasized that postoperative Day 1 imaging does not 100% predict closure rate in the immediate postoperative period when the gas is gone. This technique does make the surgery more appealing to the patient who otherwise would only lose vision and also helps minimize the physical, mental, and medical burden of postoperative recovery while maintaining equally high closure rates. Further studies are warranted to validate this process.

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Fig. 1. Study algorithm used to guide duration of facedown positioning. POD, postoperative day.

Fig. 2.

Data summary of patients undergoing 3-day prone positioning. POD, postoperative day.

Fig. 3.
Data summary of patients undergoing 7-day prone positioning. POD, postoperative day.

Fig. 4. Representative example, 3 days facedown, Case 1. **A.** Pre-operative SD-OCT. **B.** Postoperative Day 1 SD-OCT through complete intraocular gas endotamponade. **C.** Postoperative Week 1 SD-OCT. **D.** Postoperative Month 6 SD-OCT.

Fig. 5. Representative example, 7 days facedown, Case 2. **A.** Pre-operative SD-OCT. **B.** Postoperative Day 1 SD-OCT through complete intraocular gas endotamponade. **C.** Postoperative Month 1 SD-OCT. **D.** Postoperative Month 6 SD-OCT.

Fig. 6. Patient 32. **A.** Postoperative Day 1 image through intraocular gas bubble, suggesting closure of the macular hole. **B.** Postoperative Week 1 image revealing open macular hole. Inset: fundus rendered image showing <50% gas bubble. **C.** Postoperative Month 1 image showing closure of macular hole after supplemental intraocular gas and 1 additional week of facedown positioning.

Table 1

Patient Characteristics

Patient	Age	Gender	Laterality	Stage	Preoperative Latency	Preoperative Lens Status	POD 1, OCT Status
1	60	F	OD	3	6–12 months	Phakic	Closed
2	83	F	OS	4	Months	Pseudophakic	Open
3	65	F	OS	4	Unknown	Phakic	Closed
4	76	F	OS	4	5 years	Pseudophakic	Open
5	85	F	OD	4	Unknown	Phakic	Open
6	69	F	OS	3	1 month	Phakic	Closed
7	67	F	OD	3	Unknown	Pseudophakic	Closed
8	67	F	OD	4	1–3 months	Phakic	Closed
9	62	F	OS	4	Unknown	Pseudophakic	Closed
10	49	M	OS	3	2 weeks	Phakic	Closed
11	49	F	OS	4	4 weeks	Phakic	Closed
12	60	F	OS	4	Unknown	Phakic	Closed
13	65	F	OD	4	Unknown	Phakic	Indeterminate
14	71	F	OD	4, recurrent	2 months	Pseudophakic	Closed
15	74	M	OS	4	2 months	Pseudophakic	Closed
16	62	M	OS	3	2 months	Phakic	Indeterminate
17	70	M	OD	3	Unknown	Phakic	Closed
18	52	F	OD	3	Unknown	Pseudophakic	Open
19	61	M	OD	2, recurrent	2 weeks	Pseudophakic	Closed
20	63	F	OS	4, recurrent	>1.5 years	Pseudophakic	Open
21	70	M	OD	2	8 weeks	Phakic	Closed
22	62	F	OD	2	2 months	Phakic	Closed
23	57	M	OS	2, recurrent	1 month	Pseudophakic	Closed
24	73	M	OD	3	2 weeks	Phakic	Closed
25	80	M	OD	3	1 week	Pseudophakic	Closed
26	68	F	OD	2	2 months	Phakic	Closed
27	71	M	OS	2	1 month	Phakic	Closed
28	55	M	OD	3	1.5 months	Phakic	Indeterminate
29	90	M	OS	2	3 weeks	Pseudophakic	Closed

Patient	Age	Gender	Laterality	Stage	Preoperative Latency	Preoperative Lens Status	POD 1, OCT Status
30	74	F	OD	3	2 months	Phakic	Closed
31	63	F	OD	2	1 month	Pseudophakic	Closed
32	40	F	OD	3	6 months	Phakic	Closed [¶]

Patient	Facedown Duration	Stains Used	Intraocular Gas	Hole Status at Last Follow-up	Preoperative VA	Final VA	Follow-up (Days)
1	3 days	None	SF ₆ 30%	Closed	20/50	20/40	171
2	1 week	ICG	C ₃ F ₈ 15%	Closed	20/200	20/100	204
3	3 days	ICG	SF ₆ 30%	Closed	20/200	20/100	272
4	1 week	ICG	SF ₆ 30%	Open	20/100	20/125	20
5	1 week	ICG, IVT	C ₃ F ₈ 15%	Open	20/400	CF 4'	216
6	3 days	None	SF ₆ 30%	Closed	20/200	20/30	736
7	3 days	ICG	SF ₆ 25%	Closed	CF 3'	20/50	748
8	3 days	None	SF ₆ 30%	Closed	20/50	20/30	183
9	3 days	None	SF ₆ 30%	Closed	20/200	20/200	14
10	3 days	None	SF ₆ 30%	Closed	20/100	20/70	93
11	3 days	ICG	SF ₆ 30%	Closed	20/60	20/20	169
12	3 days	None	SF ₆ 30%	Closed	20/100	20/80	200
13	1 week	None	SF ₆ 30%	Closed	20/400	CF 2'	165
14	3 days	ICG	SF ₆ 25%	Closed	20/100	20/40	394
15	3 days	None	SF ₆ 30%	Closed	20/400	CF 4'*	611
16	1 week	None	SF ₆ 30%	Closed	20/60	20/20	566
17	3 days	ICG, IVT	SF ₆ 25%	Closed	20/250	20/100	241
18	1 week	None	SF ₆ 30%	Closed	20/200	20/25 [†]	517
19	3 days	ICG	SF ₆ 30%	Closed	20/60	20/50	72
20	1 week	ICG	SF ₆ 30%	Closed	CF 6'	CF 6'	197
21	3 days	ICG	SF ₆ 30%	Closed	20/200	20/50	587
22	3 days	ICG	SF ₆ 25%	Closed	20/70	20/50	554
23	3 days	ICG	SF ₆ 30%	Closed	20/200	20/30	323
24	3 days	ICG	SF ₆ 25%	Closed	20/250	20/70	406

Patient	Facedown Duration	Stains Used	Intraocular Gas	Hole Status at Last Follow-up	Preoperative VA	Final VA	Follow-up (Days)
25	3 days	IVT	SF ₆ 30%	Closed [‡]	20/60	20/30	590
26	3 days	IVT	SF ₆ 30%	Closed	20/60	20/25	344
27	3 days	None	SF ₆ 25%	Closed	20/60	20/30	515
28	1 week	ICG	SF ₆ 30%	Closed	20/70	20/40	349
29	3 days	ICG	SF ₆ 20%	Closed	20/200	20/60	311
30	3 days	None	SF ₆ 20%	Closed	20/400	CF ⁸ 8 ⁸	189
31	3 days	ICG	SF ₆ 25%	Closed	20/70	20/40	415
32	3 days [¶]	ICG	SF ₆ 25%	Closed	20/400	20/70	313

^{*} Has concurrent wet age-related macular degeneration.

[‡] Had retinal detachment repair OD 2 years before macular hole.

[‡] Hole successfully closed but reopened at postoperative Month 4 because of recurrent ERM. Hole successfully closed with repeat vitrectomy.

[§] In the presence of 3 + NS cataract, awaiting cataract extraction.

[¶] Hole read as closed by OCT on Day 1, advised 3 days facedown. Macular hole open at 1 week. Advised 1 full week of facedown after supplemental intraocular SF₆ gas with successful hole closure. No additional surgery needed.

CF, counting finger; F, female; M, male; POD, postoperative Day 1; VA, visual acuity; NS, nuclear sclerotic; IVT, triamcinolone acetate.