Recovery of Photoreceptor Layer on Spectral-Domain Optical Coherence Tomography After Vitreous Surgery Combined With Air Tamponade in Chronic Idiopathic Macular Hole

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BACKGROUND AND OBJECTIVE: Studies using sterilized air in chronic idiopathic macular holes show varying success rates, and the impact of a shorter duration of tamponade on photoreceptor layer recovery is not fully elucidated.

PATIENTS AND METHODS: Surgical outcomes of 35 cases (seven in stage 3 and 28 in stage 4) were assessed for best corrected visual acuity and with spectral-domain optical coherence tomography.

RESULTS: The primary closure rate was 91.4%, and the closed cases and unclosed cases were significantly different in the preoperative (P = .042) and postoperative (P = .040) diameter of the photoreceptor layer defect. After surgery, there was a significant improvement in best corrected visual acuity and a decrease in the photoreceptor layer defect. The postoperative logarithm of the minimal angle of resolution was significantly correlated with the preoperative hole diameter (P = .003) and the postoperative diameter of the photoreceptor layer defect (P = .005).

CONCLUSION: Air tamponade is a safe and effective treatment for chronic and severe macular holes, with several spectral-domain optical coherence tomography parameters highly predictive of postoperative visual acuity.

INTRODUCTION

Pars plana vitrectomy (PPV) has been the method of choice in idiopathic macular hole treatment since it was first described by Kelly and Wendel. Currently, the most standard procedure is PPV with peeling of the internal limiting membrane (ILM) and intraocular material tamponade followed by facedown positioning for several days. Silicone oil, octafluoropropane (C3F8), sulfur hexafluoride (SF6), and sterilized air are common tamponade materials. Although long-lasting gas is one of the most widely used tamponade materials after idiopathic macular hole surgery, it is difficult for patients to maintain facedown positioning for a long period. In contrast, sterilized air stays in the postoperative eye for a shorter time, and the macula could be evaluated earlier. Therefore, the facedown positioning period could be shortened if the hole is confirmed to close; thus, patients might be influenced less by discomfort from continuous facedown positioning.

There are several reports describing how long the proper duration of facedown positioning should be, and opinions differ from 1 day to 4 weeks. In addition, although some authors have observed recovery of the photoreceptor layer with long-lasting gas tamponade, postoperative changes on spectral-domain optical coherence tomography (SD-OCT) were seldom described in cases with air tamponade. Here we report the outcomes of 35 cases with sterilized air tamponade and 2 or 3 days of facedown positioning, with preoperative and postoperative SD-OCT findings being investigated.
PATIENTS AND METHODS

In this retrospective study, 35 eyes from 35 consecutive patients with idiopathic macular holes between January 2011 and November 2012 were analyzed. Preoperative and postoperative examinations included a Snellen best corrected visual acuity (BCVA) measurement, an intraocular pressure measurement, ophthalmoscopy, and SD-OCT using Topcon 3D-1000 Mark II (Topcon, Tokyo, Japan). BCVA was converted to the logarithm of the minimum angle of resolution (logMAR) scale for statistical analysis, and those cases with a refractive error of $-3.00 \text{ diopters}$ or more were excluded. All patients were followed up postoperatively at 48 hours, 72 hours (for macular holes remaining open at 48 hours), and 1 month.

The surgical procedures were performed by one experienced surgeon (FTD) with a 20-G system. In all eyes, the posterior hyaloid was detached followed by extensive vitrectomy excluding vitreous shaving of the vitreous base, and in five eyes phacoemulsification and intraocular lens implantation were combined. The ILM was peeled from the retina around the macular hole without prior staining with indocyanine green or other reagents. For tamponade, the vitreous cavity was filled with sterilized air. Postoperatively, all the patients were advised to maintain facedown positioning for 2 or 3 days in the hospital.

SD-OCT images were obtained 48 hours after surgery. If the hole was confirmed to close, facedown positioning was ended. If the hole did not close or if the examination was not accessible because of anterior chamber blood cells or remnant intraocular air bubbles, facedown positioning was lengthened for another 24 hours. Then, SD-OCT was performed at 72 hours after surgery, and facedown positioning was terminated. If the hole was not yet closed at that time, a second procedure was performed 1 week after the initial vitrectomy, filling the vitreous cavity with 10% C3F8.

SD-OCT scans were taken on an area of $6.0 \times 6.0 \text{ mm}$ around the macula, and the scan mode was $512 \times 128$. The macular hole diameter before surgery and the diameter of the photoreceptor layer defect before and after surgery were measured with the “caliper” mode of the SD-OCT system by one doctor (FH). Statistical analysis was performed using the independent t test and Pearson correlation analysis. A $P$ value $\leq .05$ was considered statistically significant.

RESULTS

Thirty-five eyes (21 right eyes and 14 left eyes) from 35 patients (five men and 30 women) aged 32 to 77 years (mean: 64.7 years) were included; 17 patients (48.6%) claimed a history of more than 2 years (mean: 43.2 weeks). The macular hole stages were stage 3 in seven eyes (20.0%) and stage 4 in 28 eyes (80.0%).

SD-OCT investigation could be performed 48 hours after primary surgery in 30 of 35 eyes (85.7%) and 72 hours in the other five eyes (14.3%) after surgery. The macular holes were confirmed to be closed in 32 eyes (91.4%), 29 eyes at 48 hours (Figure 1) and three eyes at 72 hours (Figure 2). Among the three eyes with open holes, two patients refused the second surgery, and the holes remained unclosed during the follow-up. The remaining case underwent a second surgery to fill the vitreous cavity with 10% C3F8 1 week later as well as a third surgery of PPV combined with 10% C3F8 tamponade 8 months later, which failed in the end.

Figure 1. A 71-year-old man (case 34) was diagnosed with a stage 4 idiopathic macular hole for 3 years and underwent vitreous surgery combined with air tamponade. (A) Preoperatively, BCVA was 0.1, and the SD-OCT image showed the macular hole and a photoreceptor layer defect of 2,894 µm. (B) The hole was closed at 48 hours after surgery. (C) One month after surgery, BCVA was 0.1, and the SD-OCT image showed the macular hole and a photoreceptor layer defect of 1,238 µm.
In all cases, the preoperative mean logMAR was 1.15 (range: 0.40–2.20), the mean hole diameter was 861.8 µm (range: 399–1,616 µm), and the mean diameter of the photoreceptor layer defect was 2,087.9 µm (range:, 867–3,444 µm). One month after surgery, the mean logMAR was 0.98 (range: 0.30–2.50), and the mean diameter of the photoreceptor layer defect was 1,424.8 µm (range: 304–2,553 µm). Thirty-two closed cases and three unclosed cases were significantly different in the preoperative (P = .042) and postoperative (P = .040) diameter of the photoreceptor layer defect (Table 1).

The factors correlated with the postoperative logMAR were examined. It showed a significant correlation between the postoperative logMAR and the preoperative hole diameter (P = .003) as well as the preoperative (P = .026) and postoperative (P = .005) diameter of the photoreceptor layer defect.

**DISCUSSION**

Although PPV with ILM peeling followed by long-lasting gas tamponade has been widely used in idiopathic macular hole surgery, it is difficult for patients to maintain an extended period of facedown positioning, and their binocular vision could be considerably impaired by persistent gas bubbles. In addition, not until more than half of the gas is absorbed could the macula be evaluated by OCT and the surgical outcome be confirmed. On the contrary, with less persistent tamponade material like sterilized air, the hole closure can be observed earlier, and the facedown positioning period can be shortened. In addition, some complications from long-lasting gas such as secondary cataracts and glaucoma could be avoided.21,22

The use of air tamponade for macular holes is not new. In 1999, Park et al8 published a study on 58 consecutive eyes with macular holes of various stages using routine ILM removal combined with air tamponade. The good visual result and the fact that the authors report no case of late reopening indicated that long-lasting tamponade was not indispensable. However, to the best of our knowledge, there has been no agreement on the choice of tamponade material or the duration of facedown positioning, especially in severe macular holes. In 2008, Eckardt et al23 reported closure rates of 54.5%, 75.7%, and 78.8% with air tamponade at 24, 48, and 72 hours after surgery, respectively, and 27.3% of their cases were categorized as stage 4. However, in 2009, Hasegawa et al24 reported a closure rate of 90.1% with 20% SF6 tamponade for 7.44 days, including 24.6% of stage 4 holes in their group. In 2013, Usui et al25 reported a closure rate of 100.0% with air tamponade in a group involving 31.8% of stage 4 holes, which was comparable with SF6 tamponade, and the hole diameter of all 22 eyes was less than 500 µm.

Our study achieved a pretty satisfactory primary closure rate of 91.4% because nearly half the cases

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**Figure 2.** A 67-year-old woman (case 30) was diagnosed with a stage 3 idiopathic macular hole for 2 years and underwent vitreous surgery combined with air tamponade. (A) Preoperatively, BCVA was 0.02, and the SD-OCT image showed the macular hole and a photoreceptor layer defect of 2,013 µm. (B) At 48 hours after surgery, the hole was not closed. (C) The hole was closed at 72 hours after surgery. (D) One month after surgery, BCVA was 0.08, and the SD-OCT image showed the macular hole and a photoreceptor layer defect of 606 µm.
had a history of more than 2 years, 80.0% of them belonged to stage 4, and the hole diameter in 85.7% cases was over 500 µm. Additionally, in the majority of our cases (85.7%), the macula could be clearly displayed on OCT at 48 hours after surgery. For the 32 closed cases, 30 (93.8%) macules were clearly displayed at that time, among which 29 holes (90.6%) proved to be closed and then facedown positioning could be terminated. Therefore, sterilized air seems to be an effective tamponade material for chronic severe macular holes. For the majority of cases, 48 hours after surgery is a good time not only for OCT evaluation of macula but also for achieving an ideal tamponade effect. For one case in this group, the macular hole closed at 72 hours after surgery, which was similar to the report by Eckardt et al.23 For the other two closed cases, the macular hole could not be displayed at 48 hours. Therefore, in such cases, it is suggested that facedown positioning be lengthened to 72 hours.

The healing of macular holes after surgery has been studied in histopathology, and Müller cell gliosis was identified as the most important factor.26 SD-OCT images can improve the understanding of the events involved in the in vivo anatomic reconstruction and provide new insights into clinical relevance of certain morphologic features. Most authors have described photoreceptor layer changes occurring after C3F8 or SF6 tamponade,16-20 and our study proved to be the first one to evaluate the recovery of the photoreceptor layer after air tamponade. Results of this study indicated that most patients experienced the recovery of the photoreceptor layer after surgery, which is displayed on SD-OCT as a reduced photoreceptor defect. We also found that both preoperative and postoperative photoreceptor defects correlated well with postoperative visual results, and they were significantly different between closed cases and unclosed ones, suggesting that the photoreceptor layer defect might be a useful parameter for predicting visual outcome as well as the chance of closure after surgery.

Our study has several limitations. On the one hand, the sample size was small because it was a single-center study. On the other hand, vision acuity and size of photoreceptor layer defect might vary with a longer follow-up period, which was only achieved in some of our cases.

In conclusion, our study confirms that the use of sterilized air tamponade could achieve a satisfactory closure rate in chronic and severe idiopathic macular holes, and with air instead of long-lasting gas, we can reliably terminate facedown positioning in most patients at only 48 hours after surgery. In addition, changes of the photoreceptor layer defect on SD-OCT represent the anatomic recovery of macular holes, which could be applied as a potential predictor for visual outcome.

TABLE

Preoperative and Postoperative Data for Idiopathic Macular Holes Undergoing Vitreous Surgery Plus Air Tamponade

<table>
<thead>
<tr>
<th></th>
<th>All Cases</th>
<th>Closed Cases</th>
<th>Unclosed Cases</th>
<th>P Value</th>
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<tbody>
<tr>
<td>Eyes</td>
<td>35</td>
<td>32</td>
<td>3</td>
<td></td>
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<tr>
<td>Mean age (years)</td>
<td>64.7</td>
<td>63.9</td>
<td>73.0</td>
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<td>Mean history (weeks)</td>
<td>43.2</td>
<td>46.2</td>
<td>12.3</td>
<td>.392</td>
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<tr>
<td>Mean hole diameter (µm)</td>
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<td>844.2</td>
<td>1049.7</td>
<td>.263</td>
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<tr>
<td>Preoperative mean BCVA</td>
<td>0.071</td>
<td>0.074</td>
<td>0.046</td>
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<tr>
<td>Postoperative mean BCVA</td>
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<tr>
<td>Preoperative mean diameter of photoreceptor layer defect (µm)</td>
<td>2,087.9</td>
<td>2,030.2</td>
<td>2,704.0</td>
<td>.042*</td>
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<tr>
<td>Postoperative mean diameter of photoreceptor layer defect (µm)</td>
<td>1,424.8</td>
<td>1,355.1</td>
<td>2,135.0</td>
<td>.040*</td>
</tr>
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</table>

*Statistically significant

REFERENCES


