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ORIGINAL PAPER

The outcomes of intravitreal C_3F_8 gas tamponade combined with laser photocoagulation treatment for optic disc pit maculopathy

Gunsu Deniz Mirza · Enver Mirza · Gunhal Satirtav · Hurkan Kerimoglu

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Abstract
Purpose To share the anatomical results and visual outcomes of intravitreal gas tamponade combined with laser photocoagulation treatment for optic disc pit maculopathy (ODPM).
Methods Intravitreal gas tamponade combined with laser photocoagulation treatment was performed on six consecutive patients with ODPM. A 0.3 mL of 100% perfluoropropane (C_3F_8) gas was injected intravitreally. The patients were then asked to maintain prone position until the C_3F_8 gas disappeared. Laser photocoagulation was performed the day after the procedure. The outcomes were determined by spectral-domain optical coherence tomography and best-corrected visual acuity (BCVA).
Results In the present study, visual improvement and reduction in serous macular detachment were observed in 83% of the ODPM patients. Complete retinal reattachment was achieved in 66% of the ODPM patients. In one patient, no regression was observed after the repeated treatment, and pars plana vitrectomy was performed. The final BCVA improved in five eyes and unchanged in one eye. No postoperative complications were observed during the follow-up period in any patient.
Conclusions Intravitreal C_3F_8 gas tamponade combined with laser photocoagulation procedure is an effective, minimally invasive, and cost-effective treatment method for ODPM.

Keyword Optic disc pit · Optic disc pit maculopathy · C_3F_8 gas tamponade · Perfluoropropane · Laser photocoagulation

G. D. Mirza (✉) · E. Mirza · G. Satirtav · H. Kerimoglu
Department of Ophthalmology, Meram School of Medicine, Necmettin Erbakan University, Konya, Meram 42080, Turkey
e-mail: gayretli.deniz@gmail.com

Introduction

Optic disc pit (ODP), which was first described by Wiethe in 1882 [1], is a congenital cavitary anomaly of the optic disc [2]. It is a rare condition with an estimated prevalence of 1 in 11.000 patients [3]. ODP is typically seen as unilateral, oval-shaped, gray-white depression and most commonly located in the temporal portion of the optic disc [4].

ODP is generally asymptomatic, but serous macular detachment develops in 25–75% of patients which is termed as ODP maculopathy (ODPM) [5]. Visual deterioration or vision loss is the most common initial complaint of the patients. ODPM may occur during childhood, but it is most common between second and fourth decades of life [6]. The pathogenesis of ODPM remains unclear, but there are several hypotheses including liquefied vitreous entering through the ODP, cerebrospinal fluid entering from the subarachnoid space through the ODP, and leakage from blood vessels at the ODP or the choroid about the origin of fluid seen in the intraretinal and subretinal spaces in the literature [7].

It is known that the prognosis is poor if ODPM patients are left untreated [6]. On the other hand, there is no accepted standard treatment method for ODPM, to date. Pars plana vitrectomy (PPV) is the most commonly used surgical procedure for the treatment of ODPM, especially in patients with vitreomacular or vitreopapillary traction [7]. Different surgical techniques such as the inverted internal limiting membrane flap, macular buckling, retinal fenestration, glial tissue removal, and autologous fibrin were also combined with PPV, but the reports evaluating these treatment modalities were limited by small sample sizes and some serious complications have been reported [8–12].

In the previous studies, alternative treatment procedures such as laser photocoagulation alone or intravitreal gas tamponade alone have been performed in patients with ODPM [13–15]. But the results were not promising. Intravitreal gas tamponade combined with prone position and laser photocoagulation treatment has better results, and this procedure may be an alternative to surgery [16, 17].

On this basis, the aim of the present study is to share the anatomical results and visual outcomes of six patients who underwent intravitreal C_3F_8 gas tamponade combined with prone position and laser photocoagulation treatment procedure for the ODPM.

Materials and methods

The file records of six patients with OPDM who were treated and followed up between January 2013 and June 2020 in the Necmettin Erbakan University, Meram School of Medicine Hospital, Department of Ophthalmology were reviewed.

All patients underwent detailed ophthalmologic examination preoperatively and postoperatively in every visit. Best-corrected visual acuity (BCVA) was recorded. Intraocular pressure was measured by Goldmann applanation tonometry. Anterior segment was evaluated with slit-lamp biomicroscopy. Funduscopic examination was performed after pupillary dilatation. Color fundus photography (TRC-50IX; Topcon, Tokyo, Japan) of the posterior segment was taken. Spectral-domain optical coherence tomography (SD-OCT; Heidelberg Engineering, Heidelberg, Germany) was performed.

Primarily, PPV was suggested to the patients for the treatment of ODPM and those who did not accept surgery received intravitreal gas tamponade combined with prone position and laser photocoagulation. All treatment procedures were performed by the same vitreoretinal surgeon (HK). The intravitreal C_3F_8 gas tamponade was performed under topical anesthesia. Paracentesis from the anterior chamber and discharge of 0.1–0.2 ml aqueous humor was followed by injection of 0.3 ml of 100% perfluoropropane gas (C_3F_8) into the vitreous cavity using a 30-gauge needle. The patients were asked to maintain prone position for at least one week, and as much as possible in the following days until the gas bubble disappears. Laser photocoagulation was performed the day after gas injection. Two to three rows of laser burns were placed to the temporal border of the ODP with a spot size of 100 µm. Exposures of 0.1 s were used and the power adjusted aiming a mild gray burn at the level of the retinal pigment epithelium.

After the treatment procedure, all patients were examined, and SD-OCT was performed at weekly intervals for 1 month, at 3-month intervals for 1 year, and every 6 months thereafter. The same treatment procedure was repeated if serous macular detachment or retinoschisis still existed or progressed during the follow-up.

Results

Clinical characteristics

This retrospective study included six eyes of three male and three female patients. The mean age of patients was 37.1 years (ranged 14–66 years). The clinical characteristics of the six patients are demonstrated in Table 1. Fundus photographs of representative patients are shown in Figs. 1a and 2a. Five patients presented with decreased vision and/or metamorphopsia in the affected eye, and one patient was diagnosed incidentally (Patient 3). The patient 5 had high myopia (> 6D), while the other patients had no significant refractive error. Vitreomacular or vitreopapillary traction was not detected in SD-OCT scans

Table 1 Clinical characteristics of the patients with ODPM

Patient	Age	Eye	Gender	Duration of Symptom	Initial BCVA	Final Retinal Results	Duration until macular attachment (months)	Final BCVA	Follow-up (months)	Additional treatment
1	48	R	M	3 months	20/200	Reattached	12	20/50	15	No
2	14	L	M	1 month	20/63	Reattached	18	20/32	32	No
3	66	R	F	Unknown	20/400	No improvement	N/A	20/400	24	Repeated treatment + PPV
4	18	L	F	7 months	20/32	Reattached	10	20/20	24	No
5	51	L	F	1 month	20/50	Reattached	1	20/32	4	Repeated treatment
6	25	L	M	2 weeks	2 mfc	Flattened	N/A	20/40	4—LTF	No

Abbreviations: *M* male, *F* female, *R* right, *L* left, *ODPM* optic disc pit maculopathy, *BCVA* best-corrected visual acuity, *N/A* not applicable, *PPV* pars plana vitrectomy, *mfc* meter finger count, *LTF* lost to follow-up

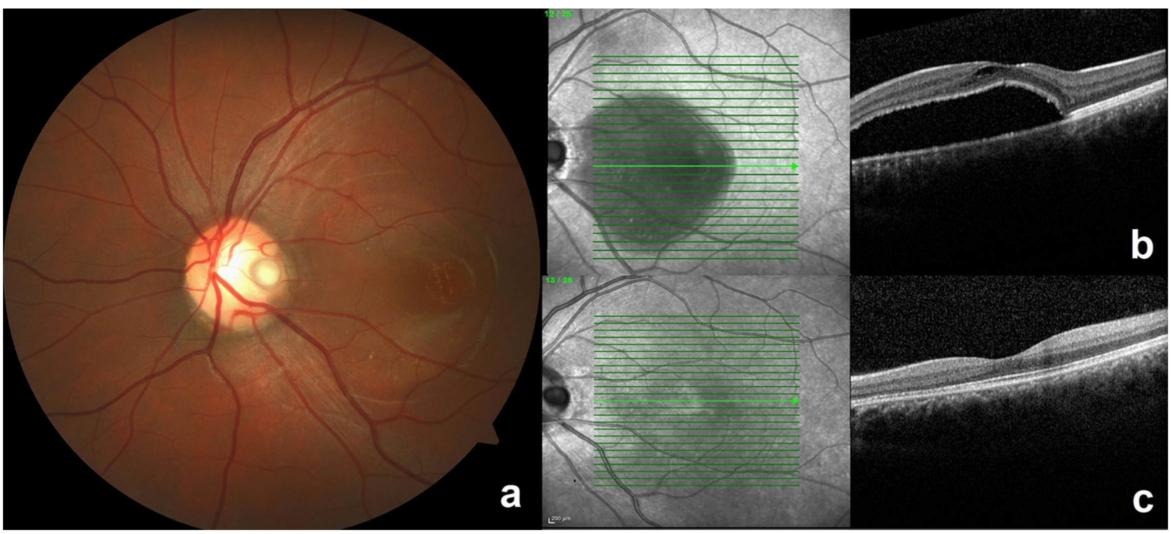

Fig. 1 a The fundus photograph of patient 4 before the treatment shows optic disc pit and serous macular detachment. **b** SD-OCT image of the same patient before the treatment shows subretinal fluid. **c** SD-OCT image of the same patient after the treatment shows retinal reattachment

at the initial examination in any patient (Figs. 1b and 2b).

Anatomic results

Complete retinal reattachment was achieved in four out of six eyes (Patients 1, 2, 4, and 5) (Figs. 1c and 2c). Among these four eyes, repeated treatment was required only in one patient (Patient 5). Reduction of the inner retinal layer schisis and outer retinal layer detachment was observed immediately after the treatment procedure. Complete fluid absorption was achieved after a mean of 10.3 months (range 1–18 months). Complete retinal reattachment was not achieved in patient 3 and patient 6. Patient 6 showed a significant decrease in serous macular detachment and retinoschisis with improved BCVA (Fig. 3a and b). However, he did not come to follow-up after the 4th-month visit. The patient was communicated by phone due to restricted circumstances in the COVID-19 pandemic and had no complaints regarding the procedure. Patient 3 showed a decrease in

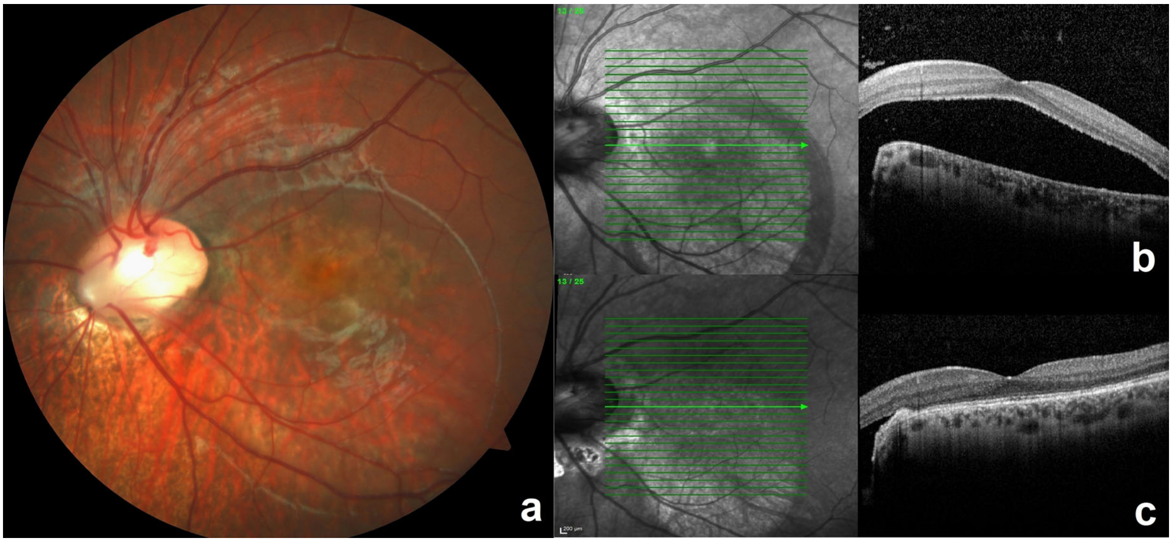

Fig. 2 **a** The fundus photograph of patient 2 before the treatment shows optic disc pit and serous macular detachment. **b** SD-OCT image of the same patient before the treatment shows subretinal fluid. **c** SD-OCT image of the same patient after the treatment shows retinal reattachment

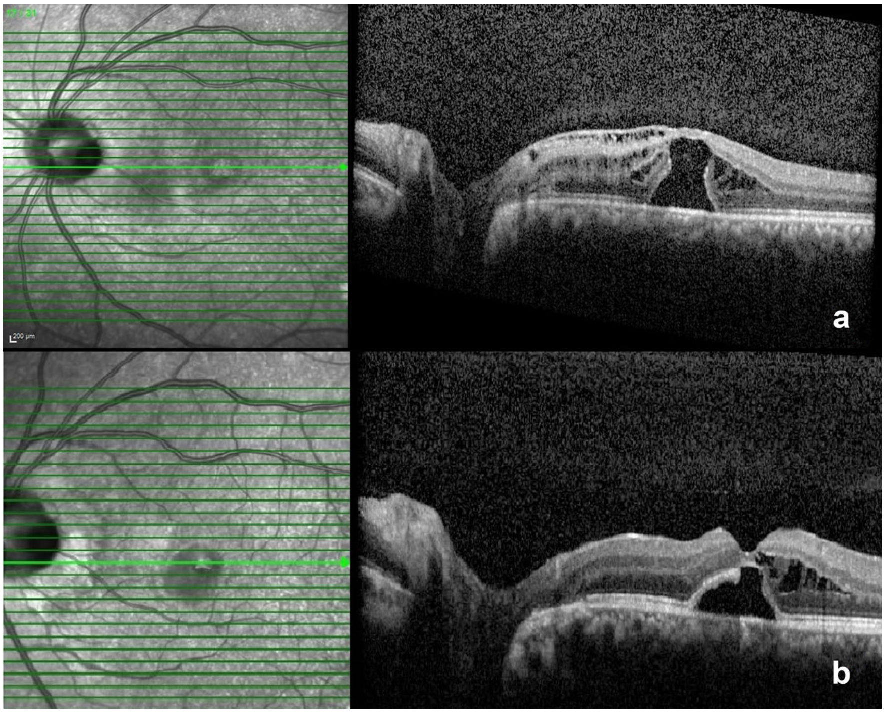

Fig. 3 **a** SD-OCT image of patient 6 before the treatment shows serous macular detachment and retinoschisis. **b** SD-OCT image of the same patient after the treatment showed a decrease in serous macular detachment and retinoschisis

serous macular detachment in the first month visit. However, it was observed that the fluid increased again, and there was no improvement in BCVA in the follow-up visits. Despite repeated treatment, no improvement was observed in the subsequent follow-ups, and PPV surgery was performed.

We should emphasize that none of four treated patients showed any recurrence after the complete retinal reattachment during the follow-up periods. The mean follow-up time of the patients, whose subretinal fluid was reabsorbed, was 17.1 months (ranged 4–32 months). No intraoperative or postoperative complications were observed in any patients.

Visual acuity results

Preoperative and the final BCVA values are shown in Table 1. The final BCVA improved in five eyes and unchanged in one eye. The mean BCVA values of the patients, which was 20/160 preoperatively, increased to 20/50 at the last examination.

Discussion

ODPM is a rare disease, and its pathogenesis is not entirely clear. The management of ODPM is still challenging for the vitreoretinal surgeons. Since significant visual loss was observed in the majority of untreated cases, numerous treatment methods have been applied for the ODPM [6]. None of them have been identified as the gold standard treatment. Nowadays, the predominant approach for ODPM management is PPV, especially in patients with vitreomacular traction (VMT) [7]. Several authors have reported the results of PPV, in combination with gas tamponade, endolaser photocoagulation, silicone oil tamponade, internal limiting membrane (ILM) peeling or subretinal fluid drainage [18–22]. These studies have shown that PPV gives very encouraging long-term anatomical, functional outcomes, and patients have satisfactory postoperative visual acuity results [18, 21, 23]. Nevertheless, the potential complications of PPV, including cataracts, retinal tear and retinal detachment, should be taken into consideration [24, 25].

Recently, in the meta-analysis of Zheng et al. six different surgical procedures including PPV alone, PPV with laser photocoagulation, PPV with ILM peeling, PPV with both ILM peeling and laser photocoagulation, PPV with inner retinal fenestration, and PPV with autologous platelet concentrate have been evaluated in the treatment of patients with ODPM [26]. The authors have investigated visual acuity changes, serous macular reattachment rate, reattachment time and macular thickness changes by OCT, and it was reported that they have not found any significant difference in functional outcomes among these six surgical procedures.

Intravitreal gas tamponade facilitates dissection of the posterior hyaloid. The prone position allows subretinal fluid to be absorbed and the retinal pigment epithelium to attach to the sensory retina. Akiyama et al. used intravitreal gas tamponade alone in patients with ODPM [27]. They reported that only four out of eight eyes had achieved complete resolution of intra-subretinal fluids. Also, repeated intravitreal gas injection was performed in three of these four eyes. Laser photocoagulation alone was also used for the treatment in patients with ODPM, but the results were not very promising [28, 29]. In addition to the intravitreal gas tamponade treatment, laser photocoagulation can block the abnormal junction between ODP and adjacent subretinal space. When they are applied together, the gas also keeps neural retina and pigment epithelium in contact near the optic nerve head to allow the laser spots to create adhesion. Therefore, it plays a critical role in reducing fluid flow from ODP to macular region [16].

Lei et al. reported that they achieved complete retinal reattachment in seven out of nine eyes with intravitreal C_3F_8 tamponade combined with laser photocoagulation. Repeated treatment was required in three of these eyes. In addition, visual improvement and significant fluid decrease were observed in the other two eyes [16]. Elmohamady et al. also applied intravitreal sulfur hexafluoride (SF_6) gas tamponade combined with laser photocoagulation in patients with ODPM. They reported that the treatment resulted in complete resolution of subretinal fluid in all of the patients. Repeated injections were required in 2 of the 11 eyes. In addition, they observed no recurrence in any of the patients during the follow-up period [17].

In the present study, after the intravitreal C_3F_8 gas tamponade combined with prone position and laser photocoagulation treatment procedure, complete retinal reattachment was achieved in four of six patients. Furthermore, serous macular detachment and retinoschisis-like changes decreased in five of six patients. Patient 6 showed a significant decrease in the serous macular detachment and his BCVA improved within 4 months of follow-up. As reported previously, a long follow-up period may be required to achieve complete retinal reattachment in some patients with ODPM. It has been observed that complete retinal attachment may take up to 18 months [16]. When the follow-up time is extended in patient 6, more acceptable treatment results are likely to be achieved.

These gases (C_3F_8 and SF_6) are used to release VMT by performing pneumatic vitreolysis as described above. It is known that C_3F_8 and SF_6 have different expansion rates inside the eye, and they last at different times in the eye. These properties are more in C_3F_8 than SF_6. In the literature, the general opinion is that C_3F_8 has better outcomes than SF_6 in patients with VMT. In the study of Guber et al., the authors have performed intravitreal gas injection in patients with symptomatic VMT, and it has mentioned that the success rate for C_3F_8 was 84% and SF_6 was 56% in those patients [30]. In another similar study, the efficacy of a single intravitreal injection of C_3F_8 and SF_6 in releasing VMT was investigated, and the researchers have concluded that intravitreal C_3F_8 injection was more efficacious than SF_6 [31]. On this basis, we have used C_3F_8 gas instead of SF_6 for the procedure that we have performed in the ODPM patients. In patient 3, because no regression was observed after the second intravitreal gas tamponade injection, PPV was performed. The reason for the failure of the technique in this patient may depend on two factors. Firstly, the age of the patient might have affected the success considering that the patient 3 was the oldest patient (age; 66) in our case series. It has been demonstrated that younger patients may have a higher chance of success in our treatment procedure [17]. She presented with asthenopic complaints, and the diagnosis was made incidentally. She did not recognize the vision loss in her eye. Probably, serous macular detachment and retinoschisis-like changes had been present for a long time. Lee et al. have supported that the delayed treatment is associated with poor anatomic and functional outcomes [16].

We have informed our patients about the benefits and complications of PPV and intravitreal gas tamponade combined with laser photocoagulation treatment procedure. In our cases, ODPM patients have preferred this procedure before PPV due to it is less invasive and has a relatively low complication rate. They have chosen PPV to be performed in the second stage in case of failure. The choice of secondary PPV can be considered reasonable because almost all of our patients did not have vitreomacular or vitreopapillary traction. However, PPV surgery was performed in one patient because no improvement was observed despite repeated treatment.

The inability to compare the effectiveness of C_3F_8 and SF_6 gas tamponades due to the small number of patients can be considered as one of the limitations of our study. Since it was done retrospectively, it was not possible to examine some data in our study. As stated, laser photocoagulation was performed to the temporal border of the optic disc. Therefore, the loss of the visual field could occur due to the damage of papillomacular bundle in the patients. The evaluation of the visual fields before and after the procedure can show the functional success of the procedure, apart from the anatomical success. Since ODPM is a rare disease, it is difficult to conduct a randomized controlled trial with a large case series. Nevertheless, the results of our study show that the anatomical and visual results of intravitreal C_3F_8 gas tamponade combined with laser photocoagulation treatment are encouraging, and this procedure can be performed under topical anesthesia confidently.

Conclusion

In the present study, we observed improvement in BCVA values and regression in serous macular detachment in 83% of the ODPM patients. Complete retinal reattachment was achieved in 66% of the ODPM patients. While making the treatment procedure decision, patient expectations should be taken into consideration. Intravitreal gas tamponade combined with prone position and laser photocoagulation procedure has a high rate of success and can be planned as an alternative treatment or can be recommended to ODPM patients before PPV.

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Availability of data and material The datasets analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Conflict of interest The authors declare that they have no conflict of interest.

Ethics approval The present study was approved by the Ethical Committee of Necmettin Erbakan University and adhered to the tenets of the Declaration of Helsinki (No.:2020/2621).

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