A prospective long-term follow-up study of optic disc pit maculopathy treated with pars plana vitrectomy, drainage of subretinal fluid and peeling of internal limiting membrane

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ABSTRACT.

Purpose: To describe the long-term results of surgical repair of patients with optic disc pit maculopathy (ODP-M).

Methods: Prospective, consecutive, noncomparative follow-up study including 12 patients with ODP-M treated by pars plana vitrectomy (PPV), peeling of internal limiting membrane followed by gas tamponade. Subretinal fluid (SRF) was drained in 11 eyes through a retinotomy without laser photocoagulation. Preoperatively, macular detachment with retinoschisis was seen in 9 out of 12 eyes with three eyes having only subretinal fluid in the macular area. The median age at surgery was 20 years (range 9–60 years).

Results: Follow-up time from initial surgery was 63 months (median). Eight eyes were anatomically reattached after one operation without remaining SRF in the macula. Two patients required a reoperation due to leakage from the retinotomy and another two underwent a second PPV procedure due to late recurrences. Successful healing was at follow-up control observed in 11 of 12 eyes. There was no statistically significant difference in visual acuity between patients before and after surgery (p = 0.24). Central visual field defects with depressed mean deviation were detected in all treated eyes.

Conclusion: In this long-term study of ODP-M final outcome regarding healing was relatively efficacious, however, a relatively large proportion had complications associated to retinotomies. We conclude that drainage of SRF should likely be avoided since it appears to contribute little to the resorption rate of SRF and seems to be linked to unnecessary risks.

Key words: long term – maculopathy – ODP – optic disc pit

Introduction

The anomaly of the optic nerve head known as optic disc pit (ODP) consists of a circular depression at the outer portion of the papillary disc, which is typically round or oval, and in the majority of cases, localized in the inferotemporal part of the disc (Kalogeropoulos et al. 2019; Uzel & Karacorlu 2019).

Histopathologic findings include herniation of dysplastic retinal tissue rich into the excavated parts of lamina cribrosa and may reach as far as into the subarachnoid space; however, evaluation using microscopy has not verified a direct communication between the subretinal and subarachnoid spaces (Christoforidis et al. 2012). Optic disc pits (ODPs) are usually sporadic without an association with systemic conditions and do not affect the disc margin. An estimation of the proportion of symptomatic patients varies between 25% and 75%, with the development of visual symptoms often first seen when the macula is affected by intraretinal or subretinal fluid, sometimes referred to as ODP maculopathy (ODP-M) (Bonnet 1991; Wan & Chang 2019). The pathophysiology of ODP-M is unclear, as is the specific origin of the subretinal fluid (SRF).

Some reports indicate that there is an association with the subretinal fluid and subarachnoid space, leading to the hypothesis that leakage of cerebrospinal fluid into the subretinal space causes the serous retinal detachment. An alternative explanation is that SRF has its origin from liquefied vitreous, which through a lamellar separation of the retina, causes a leakage at the site of ODP, resulting in retinoschisis and subsequent retinal detachment or only a localized retinal detachment (Georgalas et al. 2011; Jain & Johnson 2014).
Several therapeutic approaches have been proposed, such as laser photocogulation at optic disc rim (Theodosiadis 1977), intravitreal gas injection with or without laser treatment (Akiyama et al. 2014; Lei et al. 2015), macular buckling (Theodosiadis et al. 2015) and pars plana vitrectomy (PPV). Strategies in vitrectomy have differed regarding the removal of internal limiting membrane (ILM), drainage of subretinal fluid and intravitreal gas tamponade (Moisseiev et al. 2015; Chatziralli et al. 2018; Kalogeropoulos et al. 2019). Promising results have been reported after PPV with inner retinal fenestration close to the ODP, to allow direct fluid into the vitreous cavity (Spaide et al. 2006; Ooto et al. 2014). In order to cover the pit, some techniques have also described covering the optic disc with an inverted flap of ILM (Caporossi et al. 2018; Pastor-Idoate et al. 2019) or autologous fibrin (Ozdek & Ozdemir 2017).

Relatively few investigations have evaluated surgical and visual outcomes from a long-term perspective (Avci et al. 2013; Ooto et al. 2014; Rayat et al. 2015; Abouammoh et al. 2016; Bottoni et al. 2018; Bloch et al. 2019). In the present study, we aimed to investigate the results of patients who operated at the Örebro University Hospital for ODP, with the purpose of assessing long-term surgical results, anatomical healing, as well as present visual function and symptoms (Table 1).

**Methods**

The study was a prospective follow-up study of patients treated surgically for ODP-M and adhered to the tenets of Helsinki and the Regional Ethical Committee, Uppsala, Sweden, and was granted study permission (Dnr: 2013/154). All patients operated upon between the years 2003 and 2015 at the Department of Ophthalmology, Örebro University Hospital, due to submacular fluid secondary to ODP, were eligible for inclusion. Oral as well as written information was given to the study subjects, and an informed consent form was signed before inclusion. The follow-up protocol included a thorough ophthalmological examination, including measurements of best corrected visual acuity (BCVA, ETDRS), near visual acuity, measurement of intraocular pressure (IOP) by Goldmann applanation tonometry, and examination of anterior as well as posterior segments by two experienced vitreoretinal surgeons (KM, SC). Since the purpose was to evaluate long-term follow-up, patients were only included if the time between initial surgery and follow-up exceeded at least one year. To detect the presence of central visual field defects, a 10-2 Humphrey visual field test was conducted. Regression of subretinal fluid was evaluated by optical coherence tomography (Topcon 3D OCT-2000 and DRI OCT Triton, Topcon Corp., Tokyo, Japan).

**Surgical procedure**

Pars plana vitrectomy (20 gauge or 23 gauge) was performed in all cases by an experienced vitreoretinal surgeon, with induction of a posterior vitreous detachment (PVD) and peeling of internal limiting membrane (ILM) after dye injection. Subretinal fluid was drained through a retinotomy in all but one eye. All eyes received a vitreous gas tamponade, consisting of either 20% sulphur hexafluoride (SF6) or 16% perfluoroethane (C2F6). The pre-operative clinical assessment for retinotomy and drainage was based on the extent of submacular fluid. Subretinal fluid was drained through a retinotomy inside of the superotemporal vascular arcade without laser photoagulation. Since operations were done over an extended time period, variable size of cannulas was utilized for drainage. The first seven eyes were drained using a 25 gauge angled cannula and the last five using cannula ranging between 30 gauge and 42 gauge. The rationale for this was that resolution of subretinal fluid would occur more rapidly if drained. In cases of reoperations (see results), a PVD was confirmed in all cases, subretinal fluid was drained, and gas tamponade was given. In order to prevent potential leakage through the retinal defect from drainage, three out of four eyes were treated with laser photoagulation during the reoperation. The retinotomy site from first procedure in one eye, made with a 30 gauge cannula, could not certainty be located, and it was decided not to perform laser retinopexy.

**Statistical analysis**

Descriptive data variables were presented with median, range, mean and standard deviations. Comparison between pre- and postoperative visual acuity values was conducted using a Wilcoxon matched pairs test. Since testing preoperative visual acuity testing was done using decimal charts and follow-up by ETDRS, both pre- and postoperative values were converted to logMAR. p-values below 0.05 were considered statistically significant. Analysis was performed using IBM SPSS® 25 (SPSS Inc., Chicago, IL, USA).

**Results**

**Patients**

Specific information on each patient can be found in Table 3. The median age of patients at the time of the initial surgical procedure was 20 years and ranged between 9 and 60 years, and the majority of the patients were female (10 out of 12) and all were otherwise healthy without reported prior systemic diseases. However, one patient had intrauterine cardiac arrhythmia and another had received respiratory...
Table 3. Patient-specific information on preoperative clinical findings, therapy, and final outcome

| Patient number | Gender | Eye  | Age at PPV (years) | Symptoms/Duration | Pit location  | Other ocular findings | PPV/Tamponade | Drainage/Cannula dimension | Follow-up time (months) | BCVA Preop/postop (logMAR) | Near vision (points) | Visual field (dB) | Complication/Recurrence | Healing time (months) |
|----------------|--------|------|--------------------|-------------------|---------------|-----------------------|---------------|---------------------------|------------------------|--------------------------|-------------------------|-----------------|----------------------------|---------------------|
| 1              | Female | Left | 30                 | VA decrease/ ~6 months | Inferotemporal | Impending macular hole | Yes 20G/SF6 | Yes/25G                   | 115                    | 0.7/1.0                  | 24                      | −5.0            | FTMH/No                  | 1                   |
| 2              | Female | Right| 9                  | VA decrease/ 3 months | Temporal       | None                  | Yes 20G:23G SF6, SF6 | Yes/Yes 25G:25G | 118/72§                | 1.0/0.3                | 8                        | 1.5/1.2               | −6.8            | No/Yes*                   | 7/8                 |
| 3              | Female | Left | 18                 | VA decrease/ ~6 months | Temporal       | None                  | Yes 23G/C3F6  | Yes/25G                   | 76                     | 0.4/0.4                  | 8                       | −7.7            | No/No                     | 16                  |
| 4              | Male   | Right| 19                 | VA decrease/ >8 months | Temporal       | None                  | Yes 23G/C3F6  | Yes/25G                   | 75                     | 1.5/1.2                  | −                       | −6.8            | No/Yes*                   | 14                  |
| 5              | Female | Left | 13                 | VA decrease/ 2 months | Temporal       | None                  | Yes 23G/C3F6  | Yes/Yes 25G:25G           | 72/55                  | 0.5/1.1                  | 18                      | −18.1           | No/Yes*                   | 1/5†                |
| 6              | Female | Left | 11                 | Scotoma/5 ~6 months | Temporal       | Impending macular hole| Yes 23G/SF6  | Yes/25G                   | 72                     | 1.0/0.4                  | 8                       | −8.8            | No/No                     | 12                  |
| 7              | Female | Left | 34                 | VA decrease/ ~10 months | Temporal       | None                  | Yes 23G/C3F6  | No/-                      | 54                     | 0.3/0.1                  | 5                       | −2.3            | No/No                     | 8                   |
| 8              | Male   | Left | 50                 | VA decrease + Scotoma/ ~2 years | Inferotemporal | None                  | Yes 23G/C3F6  | Yes/42G                   | 43                     | 0.7/0.2                  | 6                       | −6.0            | NC/No                     | 43                  |
| 9              | Female | Left | 13                 | VA decrease/ ~2 years | Temporal       | None                  | No 23G/C3F6  | Yes/39G                   | 32                     | 0.2/0.1                  | 5                       | −1.8            | No/No Retinal tear/No    | 32                  |
| 10             | Female | Right| 21                 | VA decrease/ >1 year | Inferotemporal | Full-thickness macular hole| Yes 23G/C3F6  | Yes/39G                   | 20                     | 0.7/0.4                  | 8                       | −9.4            | No/No                     | 20                  |
| 11             | Female | Left | 60                 | VA decrease + metamorphopsia/ Unspecific, years | Temporal | None                  | No 23G:2G C3F6, C2F6 | Yes/Yes 30G:30G | 39/27§                | 0.3/0.5                | 12                      | NC                | No/No                     | 27†                 |
| 12             | Female | Right| 32                 | VA decrease/ 7 months | Temporal       | None                  | No 23G:2G C3F6, C2F6 | Yes/Yes 30G:30G | 37/11§                | 0.3/0.2                | NC                      | NC                | No/No                     | 11†                 |

NC = Not conducted.
* 43 months postoperatively.
† 14 months after first PPV.
‡ Subretinal fluid confirmed again on follow-up visit.
§ Follow-up time after second vitrectomy.
¶ Incomplete regression of SRF after first operation. Healing time calculated from second PPV procedure.
support in the postnatal period. In two other patients, allergic conjunctivitis and some degree of amblyopia in the affected eye was reported (patient no. 8) prior to detection of ODP. All patients had subjective symptoms coupled with a deterioration in visual acuity, and the majority had experienced loss of vision for several months, some with unspecific duration. Peripapillary laser photocoagulation had been performed in one eye (patient no. 3) more than ten years before referral to our unit, due to the recurrence of symptoms and SRF in the macula. Furthermore, one patient (no. 12) had initially healed spontaneously without therapy before the recurrence of ODP-M four years later. Three patients reported sudden symptomatic onset, one of which was directly after a blunt head trauma (no. 7). Preoperative OCT examinations displayed subretinal fluid in the macular region, in combination with retinoschisis in the majority of treated eyes. In two eyes with retinoschisis, an impending macular hole was seen, and in another, a full-thickness macular hole (FTMH) was confirmed on OCT. Four patients were included in a previous publication, in which evaluation of SRF regarding concentration of Beta-trace protein was performed; however, the follow-up control was not part of that study.

The follow-up time was calculated in completed months from the initial operation.

Eight patients were operated once, and four had to undergo two surgeries, because of incomplete resorption of SRF from suspected leakage through retinotomies (patients no. 11 and 12) and two due to late recurrence of the detachment, 13 and approximately 36 months, respectively, after OCT-verified healing. In the two cases of late recurrence, healing after the second PPV was confirmed after 5 and 8 months, respectively. However, in the former patient, a low level of subretinal fluid was found anew in the macular region at control visit 55 months after the reoperation. In the two eyes where leakage through retinotomy was suspected, complete regression of subretinal fluid took place 11 and 27 months postoperatively. In general, regression of subretinal fluid was slow but complete regression of subretinal fluid was achieved in all but one patient. One eye with an impending macular hole postoperatively progressed to a FTMH, but the patient declined further surgery (no. 1). The second eye with retinoschisis combined with impending macular hole as well as the eye with FTMH preoperatively healed after surgery. One eye developed a retinal tear during induction of PVD, which was treated with laser photocoagulation peroperatively. One eye underwent uncomplicated cataract surgery during the follow-up period (patient no. 11). None of the eyes developed a rhegmatogenous retinal detachment during the study period.

Postoperative healing time was defined as complete regression of subretinal fluid on OCT after the initial operation. At the follow-up examination, eight eyes had improved visual acuity, three had deteriorated, and one eye had unchanged levels. Nevertheless, visual acuity was in general relatively low at the postoperative control visit (median 0.4 logMAR). There was no statistically significant difference in

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Fig. 1. (A) A preoperative image with ODP-M without retinoschisis (patient no. 12). (B) OCT picture at follow-up visit. No subretinal fluid remains, but a scar is seen temporal of macula (left) after drainage and laser photocoagulation from second PPV.

Fig. 2. (A) Retinoschisis and subretinal fluid including the macular region (patient no. 8). Note the attached and condensed posterior vitreous membrane overlying the ODP. (B) No retinoschisis or SRF is observed at postoperative control.
The intraocular pressure was normal in the ODP-M or attributed to surgery. Not considered to be associated with sensitivity in the red-green spectrum was found (patient no. 8), which was vision was normal in all but one male eyes in OCT examinations. Colourular region, was achieved 11 out of 12 absence of subretinal fluid in the macular area, was achieved 11 out of 12 eyes in OCT examinations. Colour vision was normal in all but one male patient, in which a slight reduced sensitivity in the red-green spectrum was found (patient no. 8), which was not considered to be associated with the ODP-M or attributed to surgery. The intraocular pressure was normal in all eyes.

**Discussion**

Management of ODP-M is still controversial, with reports of several different successful strategies. In this article, we describe long-term results after treatment by pars plana vitrectomy with ILM peeling and gas tamponade. In addition to this, drainage of submacular fluid through a paracentral retinotomy was performed in 11 of the treated eyes. A successful anatomical result was achieved in 92% of the eyes; however, four patients required two operations to achieve anatomical healing.

In general, the patients had relatively low visual acuity levels, which may indicate that over time the macular function could be negatively influenced by the macular detachment. However, near visual acuity, which often corresponds better to a decline in macular function (Frennesson et al. 2010), was, in the group as a whole, not severely impaired, especially if excluding eyes with remaining SRF, FTMH or reoperations. One eye nonetheless had severely reduced macular function although anatomical healing was achieved without complications.

Disappearance of subretinal fluid was slow in most treated eyes although two eyes already had no subretinal fluid after one month postoperatively. The time for restitution of macular status did, in most cases, not seem to be positively influenced by performing a retinotomy and drainage of subretinal fluid, when compared to what has previously been published (Avci et al. 2013; Rayat et al. 2015; Avci et al. 2017; Bottino et al. 2018). It is noteworthy that two eyes had late recurrences of the serous detachment more than a year after the initial successful PPV surgery. Even though fluctuating course of the disease has been reported, with ODP-M healing spontaneously (Bloch et al. 2019) and after PVD (Bonnet 1991; Gupta & Choudhry 2016) as well as reappearance of a macular detachment long after successful surgery (Coca et al. 2014), it is not unlikely that all cases of recurrences and inadequate healing were associated with retinotomies. Our interpretation is that drainage of SRF does not clearly contribute to healing of the condition but could rather be the cause of unnecessary complications and should probably be avoided. Furthermore, it is also plausible that unnecessary visual field defect can be avoided if drainage is not performed.

One eye with an impending macular hole developed a full-thickness macular hole after treatment, which was not subjected to further surgical procedures. Macular hole formation in ODP management has previously been described and is a known complication associated with management of ODP-M (Rizzo et al. 2012; Ooto et al. 2014; Avci et al. 2017; Bloch et al. 2019). Aside from the retinotomy-associated problems described above, no postoperative complications were detected among the eyes treated.

The exact nature of the ODP is unknown, as is the origin of subretinal fluid. We have previously published data where the subretinal fluid was evaluated for Beta-trace protein, which is utilized to detect the presence of cerebrospinal fluid (Makdoumi et al. 2017). These findings indicate that SRF in ODP-M does not have levels of the protein consistent with CSF and may support the hypothesis that the fluid originates as a result of vitreous traction associated with the optic disc anomaly. In one of these patients, the development of the macular detachment appeared after a head trauma and further supports the idea that tractional forces at the posterior hyaloid interface are at least of importance in the development of SRF.

The visual field defects observed were likely to primarily be due to deterioration of macular function after long-standing subretinal fluid in the macular area and affected nerve fibre layer associated with the optic disc anomaly, but more peripheral perimetry would likely have confirmed scotomas associated with retinotomies, which further supports the concept that unnecessary retinotomies should be avoided.

We consider the prospective design of this study, with a median duration from the initial surgical treatment exceeding five years, consecutive inclusion, as well as the thorough clinical evaluation, some of the strengths of the evaluation.

Limitations of this study include that the number of subjects is low and that patients were not prospectively included, with the consequence that preoperative data were gathered from patient journals and OCT images. In
addition to this, some of the patients treated during the time period were not interested in participating in the study, justifying that some data during the time period were not included in the study.

Optic disc pit-M is an intriguing condition in which the exact pathogenesis is as yet incompletely investigated and understood. Complications associated with retinotomy in these eyes were fairly common, although healing was ultimately achieved in all but one treated eye. We will, nonetheless, be more cautious regarding SRF drainage, given that recurrences could be linked to the surgical method and did not seemingly shorten the healing time considerably. As anatomical healing can be achieved by pars plana vitrectomy with induction of PVD (Hirakata et al. 2005) even without a gas tamponade (Hirakata et al. 2012), it is possible that additional measures may add little to promoting the regression of SRF. We consider the removal of ILM as an effective means of confirming a PVD associated with relatively low risk and gas tamponade might promote healing of the retinal tissue, but we hope future studies will indicate directions for optimum strategies regarding management of ODP-M and further reveal the pathogenesis of the condition.

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