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ARTICLE

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Two-port dry vitrectomy for rhegmatogenous retinal detachment: a pilot study

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OBJECTIVE: To evaluate the safety and efficacy of a new surgical technique for the management of primary rhegmatogenous retinal detachment (RRD), consisting of localized PPV near the retinal break(s), without infusion line, associated with a drainage of subretinal fluid and cryoretinopexy.

METHODS: Multicentric prospective study conducted at the University Hospital of Cagliari and IRCCS Fondazione Policlinico Universitario A. Gemelli, Roma. Twenty eyes affected by RRD with the causative retinal break(s) in the superior meridians were enrolled between February 2022 and June 2022. Patients with cataract ≥3, aphakia, significant posterior capsule opacification, giant retinal tears, retinal dialysis, history of trauma and PVR ≥C2 were excluded. All eyes underwent a two-port 25-gauge PPV with localized removal of the vitreous surrounding retinal break(s), followed by 20% SF6 injection and cryopexy. The surgical time was recorded for each procedure. Best-corrected visual acuity (BCVA) was measured at baseline and postoperative 6 months.

RESULTS: Primary anatomic success at 6 months was achieved by 85% of patients. No complications occurred, except for three (15%) retinal re-detachments. The average surgical time was 8.61 ± 2.16 min. Overall, the difference between pre- and last postoperative mean BCVA was statistically significant ($p = 0.02$).

CONCLUSIONS: Two-port dry PPV demonstrated safety and efficacy for the treatment of RRD, reaching an 85% of anatomical success rate. Although further studies are necessary to confirm the efficacy and long-term benefit of this treatment, we believe that this surgical technique could be considered a valid and safe alternative for the management of primary RRD.

Eye; https://doi.org/10.1038/s41433-023-02617-6

INTRODUCTION

Retinal detachment (RD) is defined as the separation of the neuroepithelium from the retinal pigment epithelium, depriving the retinal cells from the layer of blood vessels that provides oxygen and nourishment. The most common cause of this disease is the recruitment of fluid from the vitreous cavity into the subretinal space via a retinal break (tears or holes). This so-called rhegmatogenous RD (RRD) is a potentially blinding condition and it has an incidence of about 10/100,000 [1–3]. The management of RRD is surgical and the principles of surgery include the relief of the vitreous traction and the break closure [4].

The main surgical interventions currently used are scleral buckle (SB), pars plana vitrectomy (PPV), which could be performed alone or combined, and pneumatic retinopexy (PnR). Although certain clinical presentations may guide the choice towards a surgical approach over another, the management of many common configurations of RRD remains controversial [5].

The PnR represents the less invasive procedure, consisting of intravitreal injection of an expandable gas and further retinopexy [5]. Severe intraoperative complications are rare, but the inability to relieve the vitreous tractions leads this procedure to a median success rate of 69%, lower if compared to the other techniques [6]. Hence, this intervention is recommended for selected cases, such as eyes with an RRD due to a single small retinal break or a group of breaks within 1 h within the superior 8 clock hours of the retina [7]. Moreover, many factors, including lens opacity and small pupils, could be a limit for this technique due to the difficulty of identifying retinal breaks preoperatively [8].

SB consists of an ab externo approach through which retinal break closure and vitreoretinal tractions' neutralization are obtained with a placement of a buckle or a plombage indenting the sclera. This procedure still remains the gold standard procedure in some circumstances, as in phakic eyes and young patients [5, 9, 10]. However, it is associated with not uncommon intraoperative and postoperative complications (scleral perforation, subretinal hemorrhage, choroidal detachment, diplopia, high refractive error, chronic pain or explant exposure) [5].

PPV, introduced by Robert Machemer around the 1970s, directly removes the vitreous traction removing the whole vitreous. Therefore, the break closures are achieved by the direct pushing effect of a tamponade agent on the retina. The reduction in invasiveness and the refinement of PPV made it the most

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Received: 18 January 2023 Revised: 13 May 2023 Accepted: 2 June 2023
Published online: 10 June 2023

commonly performed intervention for RRD worldwide [11, 12]. Nevertheless, PPV is still associated with a series of complications such as iatrogenic retinal tears and increased postoperative intraocular pressure (IOP) [5]. Moreover, many studies have demonstrated that a complete vitrectomy, requiring prolonged time inside the vitreous cavity (phototoxicity), promotes an inflammatory response which represents a risk for the development of vitreoretinal proliferation and increases oxygen levels in the vitreous chamber causing cataract progression [5, 13–15].

For these reasons, in the last years, scientific research was focalized to reduce the vitreous manipulation and the time of surgery keeping the same efficacy. Recently, two similar techniques have been reported, consisting of a limited vitrectomy under air only near the retinal break with the aim of releasing vitreous tractions and draining the subretinal fluid [15, 16].

The aim of this study was to evaluate the safety and efficacy of a new surgical technique consisting of a dry localized two-port vitrectomy close to the causative retinal break/s and drainage of the subretinal fluid followed by a cryoretinopexy, for the management of RRD.

MATERIALS AND METHODS

Study design and patients' selection

This was a prospective multicentric study conducted at the University Hospital of Cagliari, Italy, and at IRCCS Fondazione Policlinico Universitario A. Gemelli, Roma, Italy. Twenty eyes of twenty patients with RRD were included in the study between February 2022 and June 2022. All of them underwent to a complete ophthalmic examination by a retinal specialist in both centers to assess if all the inclusion criteria were met.

All study patients presented with a treatment-naïve RRD, both macula on and off, which involved the superior, temporal and/or nasal quadrants. The retinal break/s had to be in the superior meridians (between 8 o'clock and 4 o'clock) (Fig. 1).

They could be pseudophakic or phakic patients, with a ≤grade 2 cataract in Thompson grading [17]. Individuals with any refractive status, including high myopia, were included. A mild localized vitreous hemorrhage was tolerated, as long as the optic disk, the retinal vessels and the whole periphery were clearly visible.

Patients with any other type of RD (exudative, tractional or mixed) were excluded from the study. Other exclusion criteria were RDD with the only break situated in the peripheral retina between 5 and 7 o'clock meridians, or any break located too posteriorly to be treated with the cryoretinopexy. Also, patients with cataract ≥grade 3 (Thompson's grading [17]), aphakia, significant posterior capsule opacification, giant retinal tears, retinal dialysis, any history of trauma, proliferative vitreoretinopathy (PVR) ≥grade C2 [18], diabetic retinopathy, age-related macular degeneration or any other retinal or macular disease that could affect the post-surgical visual outcome were excluded. Patients with any cognitive deficiency, which may prevent them from fully understanding their pathology and the necessity for strict head positioning, were not included in this pilot study.

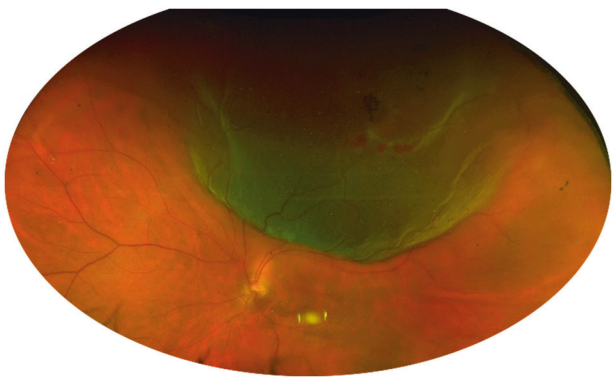

Fig. 1 Preoperative fundus picture of 22-year-old patient. Left eye, superior RRD with a group of breaks between the 1 and 2 o'clock meridian (Fundus picture with Optos® California – Optos, Marlborough, MA, USA).

The study adhered to the Declaration of Helsinki. The protocol used was approved by both local Institutional Review Boards (NP/2022/785-1381 – VitMininv_IDstudio5098). Informed consent was obtained before enrollment from all participants.

Surgical technique

The surgeries were performed by a single surgeon for each center (EP and TC) under local anesthesia (parabulbar block by 5 cc Lidocaine and 5 cc Bupivacaine). Surgical procedures were performed using Constellation® Vitrectomy system (Alcon, Fort Worth, TX, USA) and BIOM wide-angle viewing system (Oculus Optikgeräte GmbH, Wetzlar, Germany) in Cagliari and with the Constellation® and the NGENUITY® 3D Visualization System (Alcon, Fort Worth, TX, USA) in Rome. After the disinfection of the surgical field with 5% povidone-iodine application for 2 min, two 25G valved trocars were inserted at 3.5 (pseudophakic) or 4 mm (phakic) from the limbus in the superotemporal and superonasal quadrants. The detachment was then visualized using the light pipe and the wide-angle/3D visualization viewing system. As a first step, the retinal periphery was checked to identify any rhegmatogenous lesion or secondary tear to be treated with cryoretinopexy before vitrectomy. Then a localized PPV close to the main retinal break was performed with the 25G vitrectomy, under light pipe illumination, without any infusion system (cut rate 10,000 cpm, maximum vacuum 650 mmHg). The restricted vitrectomy allowed us to release any vitreal tangential traction force on the retina and drain all the possible subretinal fluid (Fig. 2).

Specifically, the active aspiration with the vitrector was carefully managed switching the cutter to on/off mode and setting a proportional variation of vacuum from 0 to 650 mmHg, in order to gently remove the subretinal fluid. During this phase, it was crucial to assess if any hypotony occurred and eventually refill the vitreous chamber with a mixture of 20% sulfur hexafluoride (SF6) and air. This surgical step (vitrectomy and refill) has been repeated from one to three times in our series of patients, varying the amount of mixture of gas between 2 and 10 ml, based on the amount of colliquated vitreous under the retina. Moreover, the retinal artery perfusion was carefully checked under direct visualization of the fundus during the vitrectomy and refilling procedure. This maneuver allowed us to remove any possible vitreous traction left on the main break and helped to proceed with the subretinal fluid drainage using the vitrector. Once the vitrectomy procedure had been completed, an additional 20% SF6 injection was performed to reach a proper filling of the eye and the IOP was digitally checked while injecting. A cryopexy treatment was performed on the main retinal tear as a last step.

With no need of paracentesis, the trocars were finally removed and an antibiotic ointment was applied on the eye. Then, the patients were placed face down for 1 h after surgery to avoid any fluid slippage and the IOP was checked again before their discharge. Patients were instructed about the correct head positioning for the 5 days after surgery, according to the localization of the breaks, and a steroid-antibiotic association drop is prescribed four times per day.

Follow-up

Follow-up visits were performed on day 1, 1 week, 1 month, 3 months and 6 months after surgery by a retinal specialist in both centers. At day 1, an anterior segment evaluation, IOP measurement and indirect ophthalmoscopy were performed. In some cases, a fundus photography has also been taken to better assess the gas filling (Fig. 3).

At the following visits, the best-corrected visual acuity (BCVA) was collected and an optical coherence tomography (Spectralis OCT, Heidelberg Engineering, Germany) was performed along with the other evaluations.

The visits were performed to rule out any infection or inflammation sign. Surgical failure was defined as persistent postoperative SRF contiguous with the retinal break, requiring a secondary intervention to reattach the retina. Progression of cataract within 3 months of the primary procedure was attributed to the surgical intervention and was considered as a complication. A rise in IOP during the follow-up was another complication that was considered, taking into account if the patient could be considered a steroid-responder.

Statistical analysis

Data were recorded on Microsoft Office Excel (Microsoft Corporation, Redmond, WA, USA) and the statistical analysis was performed using Excel

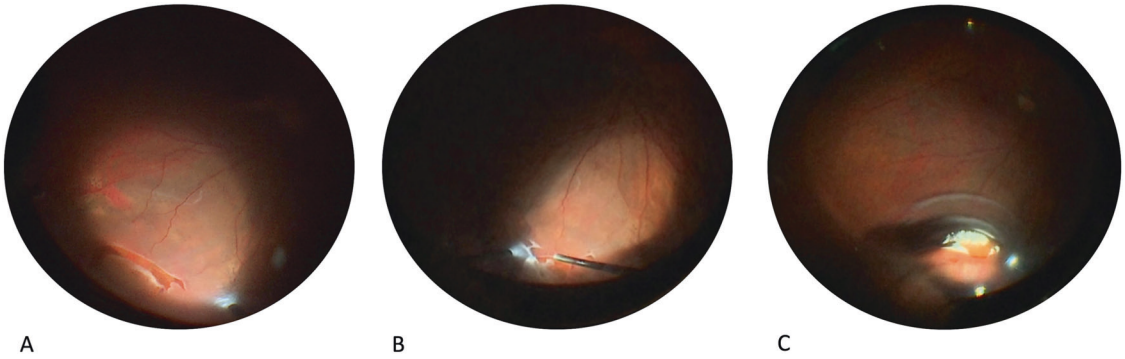

Fig. 2 Two-port dry vitrectomy. Intraoperative photographs showing a left eye superior RRD with a large superior break (**A**), treated with a localized pars plana vitrectomy (PVV) near the retinal break, without the infusion line, associated with a drainage of the subretinal fluid (**B**) followed by a cryoretinopexy (**C**).

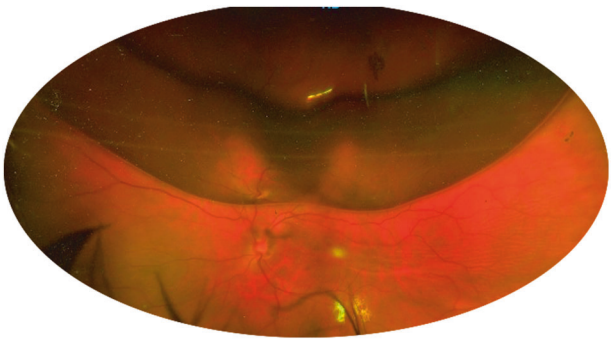

Fig. 3 Postoperative day 1 fundus picture. Patient of Fig. 1, with a partial gas fill of the vitreous chamber following two-port dry pars plana vitrectomy and injection of a mixture of 20% sulfur hexafluoride (SF6) and air (Fundus picture with Optos® California – Optos, Marlborough, MA, USA).

and SPSS Statistics v28.0 (IBM Corp., Armonk, NY, USA). Snellen visual acuity values were converted to the logMAR values for subsequent analysis. The Kolmogorov–Smirnov test was used to evaluate the normal distribution for each variable. Student *t*-test or Wilcoxon rank sum test was used to compare continuous variables before and after the operation. *P* values <0.05 were considered significant.

RESULTS

Twenty eyes of twenty patients affected by RRD following the inclusion criteria were enrolled. Nine eyes (45%) were high myopic with a mean axial length of 30 mm (range 26.40–35.07 mm). The mean duration of symptom onset was 3 days with a range of 1–5 days.

All demographical and preoperative data are summarized in Table 1.

The average surgical time was 8.61 ± 2.16 min. All the patients completed the 6-month follow-up. The anatomical success rate, defined as retinal reattachment at the final follow-up of 6 months after a single operation, was 85%. Only three patients (15%, two "macula on" and one "macula off") did not reach the main outcome of the study, showing a retinal re-detachment in the first month, between the first and the second week. All the 17 eyes (85%) who gained a complete retinal reattachment, did not develop any surgical-related complications.

The mean preoperative BCVA (T0) was 20/80 Snellen (0.61 logMAR), with a range 20/20 to 20/4000 Snellen (0.00–2.30 logMAR), while the postoperative 6 months (T6) BCVA was 20/25 Snellen (0.12 logMAR), with a range of 20/20 to 20/200 Snellen (0.00 and 1 logMAR). Overall, the difference between T0 and T6 mean BCVA was statistically significant ($p = 0.02$).

Table 1. Demographical and preoperative data.

Variable	Study group ($n = 20$)
Age (y), mean (SD)	54.6 (12.56)
Sex	
Male, *n* (%)	11 (55%)
Female, *n* (%)	9 (45%)
Eye	
Right, *n* (%)	8 (40%)
Left, *n* (%)	12 (60%)
Refractive status (SE), mean (SD)	–2.86 (3.83)
Axial length (mm), mean (SD)	25.92 (2.73)
Lens status	
Pseudophakic, *n* (%)	2 (10%)
Phakic, *n* (%)	18 (90%)
Grade 0, *n* (%)	5 (27.78%)
Grade 0.5, *n* (%)	5 (27.78%)
Grade 1, *n* (%)	7 (38.89%)
Grade 2, *n* (%)	1 (5.56%)
Macular status	
Macula on, *n* (%)	11 (55%)
Macula off, *n* (%)	9 (45%)
Duration of symptoms (days), mean (SD)	3 (1.45)
Number of breaks, mean (SD)	1.6 (0.82)
Quadrants (*n*), mean (SD)	1.5 (0.5)
Preop BCVA	
Overall (logMAR), mean (SD)	0.61 (0.74)
Macula on (logMAR), mean (SD)	0.08 (0.12)
Macula off (logMAR), mean (SD)	1.24 (0.66)
Preop IOP (mmHg), mean (SD)	15.9 (2.53)

BCVA best-corrected visual acuity, *IOP* intraocular pressure.

In the "Macula on "group (11 eyes on 20, 55%), the T0 BCVA was 20/25 Snellen (0.08 logMAR), with a range of 20/20 and 20/40 Snellen (0.00–0.30 logMAR). The mean postoperative 7 days (T7d), 1 month (T1), 3 months (T3) and T6 BCVA were 20/20 (0.04 logMAR), 20/20 (0.00 logMAR), 20/20 (0.00 logMAR) and 20/20 (0.00 logMAR) respectively. The difference between T0 BCVA and postoperative BCVA at T7d, T1, T3 and T6 follow-up was not statistically significant ($p = 0.76$, $p = 0.17$, $p = 0.17$ and $p = 0.17$, respectively) (Fig. 4).

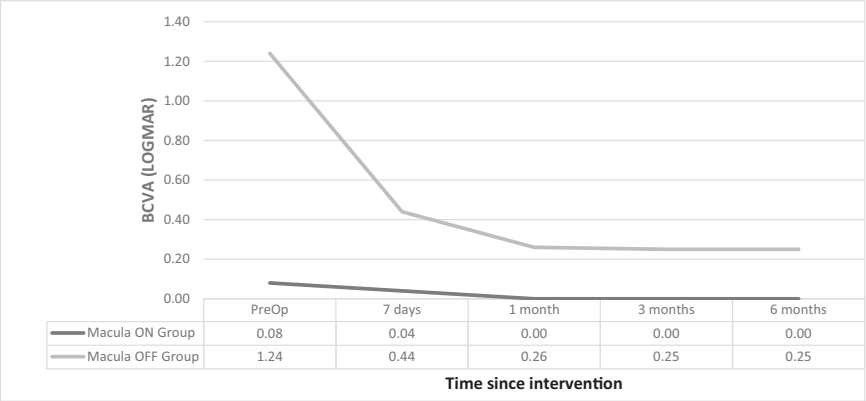

Fig. 4 Macular involvement in rhegmatogenous retinal detachment and BCVA changes. Graph showing mean BCVA values in LogMAR units from baseline to month 6 according to the groups (macula-on and macula-off RRD).

In the "Macula off "group (9 patients), the mean preoperative BCVA was 20/320 Snellen (1.24 logMAR), with a range of 20/63 and 20/4000 Snellen (0.50–2.30 logMAR) The mean 7 days, 1 month, 3 months, 6 months BCVA were 20/50 (0.44 logMAR), 20/32 (0.26 logMAR), 20/32 (0.25 logMAR) and 20/32 (0.25 logMAR), respectively (0.19 logMAR). The difference between preoperative (T0) and postoperative BCVA at 7 days (T7d), 1 month (T1), 3 months (T3) and T6 follow-up was statistically significant ($p < 0.01$, $p < 0.01$, $p < 0.01$ and $p < 0.01$, respectively) (Fig. 4).

The extension of RD was at most two quadrants, with single or double tears localized in the superior meridians. We have recorded three complications that occurred within the first month, all represented by the recurrence of RD. Two of these patients were treated with standard three-port PPV with SF6 20% as endotamponade, whereas, for one patient, the silicon oil 1000 cts was used as endotamponade. No other complications, including cystoid macular oedema (CMO), new posterior vitreous detachments, epiretinal membrane or PVR, occurred during the 6-month follow-up.

DISCUSSION

Although the eye seems to get by without the vitreous after its removal by PPV, this transparent crosslinked hydrogel plays an important role in the mechanical and molecular homeostasis of the eye [19–21]. Indeed, due to the presence of collagen, hyaluronan and their interactions, the vitreous body has viscoelastic properties that allow it to absorb energy rapidly and release it slowly. In addition, the normal vitreous, probably related to the high level of ascorbic acid, keep the oxygen levels low [20]. Hence, the increased oxygen levels in the vitreous chamber after vitrectomy lead to oxidative stress that may result in cataract, late-onset open glaucoma and PVR [22–24]. Moreover, another content of the vitreous, thrombospondin, seems to be responsible for its antiangiogenic and antineoplastic features [21].

Under this light, a vitreous-sparing procedure could be thought of as a reasonable option in the management of RRD. Nevertheless, vitreous-sparing procedures, SB and PR, presented some issues which make PPV the most performed surgical procedure for RRD in most of the world [13].

SB, although recent studies have reported a high anatomical success (53–83%), still remains a complicated surgery with a high risk of intraoperative and postoperative complications [5, 9]. On the contrary, PnR is a simple and minimally invasive procedure, but in terms of efficacy, recent studies have shown a primary success rate between 73% and 81%, while lowering in aphakic and pseudophakic eyes (41–67%) [7, 25, 26]. Indeed, after this procedure, the discovery of new retinal tears or the visualization of other tears not previously identified was very common (12–23%) [6]. This aspect seemed related to the no wide-angle visualization and to the stretching of the vitreous from the growing gas bubble in a limited space, generating tractions in other areas of the retina and leading to new breaks. Therefore, this intervention still remains recommended for selected cases, such as eyes with an RRD due to a single small retinal break or a group of breaks within 1 h within the superior 8 clock hours of the retina [6].

Actually, PPV was performed for the majority of RRDs and resulted very successful. According to the two large comparative randomized studies of Heimann et al. (PPV against SB) and Hillier et al. (PPV against PnR), the primary anatomical success for vitrectomy was 72% and 93%, respectively [7, 9]. Nevertheless, PPV is associated with specific complications, such as iatrogenic retinal tears, lens touch, cataract formation, CMO and increased IOP [23, 27–29]. Moreover, the time of surgery and manipulations inside the vitreous chamber could influence the complication rates, such as phototoxicity [30].

For all these reasons, the development of less invasive techniques has been investigated in recent years. In 2018, Bonfiglio et al. published their experience of a localized vitrectomy with 94% of success for a single surgery and 100% success after additional procedures for 32 eyes affected by macular ON detachment [16]. The technique described by the authors has involved the use of three 25G trocars to remove the vitreous tractions around the retinal rupture under air (continuous infusion at 30–35 mmHg) and to drain the subretinal fluid through the rupture, then treated with an endolaser. No central vitrectomy or "shaving" of the vitreous base has been performed [16], whereas a similar procedure, called "minimal interface vitrectomy" and characterized by a sectorial vitrectomy (25G) under air (continuous infusion at 35 mmHg), has been described by Mura et al. [15]. Differently from the previously described technique, this procedure included a partial vitrectomy in the center of the vitreous chamber to allow adequate tamponade with air or gas (SF6). The authors reported an anatomical success of 100% on 12 eyes [15].

The aim of our study was to develop a different surgical technique for the management of a RRD, comparable to PnR in terms of vitreous preservation and surgical timing, and at the same time similar to three-ports PPV in terms of efficacy and safety. Compared to the standard PPV, our procedure has several advantages. First, considering the average operation duration of 8.61 ± 2.16 min, it has reduced the total surgical time. Our two-port dry vitrectomy was rapid and used less incisions and minimal vitreal manipulation with a supposed reduction in inflammatory response. Consequentially, no PVR or anterior chamber inflammation has developed in any of our patients during the follow-up period.

Similarly, considering all the twenty eyes of our study, no postoperative CMO has been recorded, which represents a common complication in standard PPV [31]. In fact, recent studies highlighted a higher incidence of CMO after RRD repair with PPV,

either alone or combined with phacoemulsification, than SB [31]. Probably, also the use of cryotherapy retinopexy instead of endolaser retinopexy plays a role in lowering the risk of postoperative CMO [29]. Furthermore, limited vitreous removal with preservation of cortex, which protects the crystalline lens from excessive oxygen exposure, reduces cataract formation [22]. Although the previously reported complications could be observed in a longer follow-up of our technique, in our population, no opacification of the lens nor other complications have been observed during the follow-up. Moreover, no posterior vitreous alterations have been demonstrated in the postoperative period.

Compared with the other localized PPV procedures [15, 16], the innovation of our two-port dry PPV is to remove the vitreous surrounding the retinal breaks without any infusion and vitreal hydration. Consequentially, we preserved the vitreal gel with its structure and antioxidant properties to reduce the onset of postoperative inflammation, and, simultaneously, we removed the colliquated vitreous under the retina in order to create more space for the gas injection and to shorten the time of subretinal fluid reabsorption. Indeed, in comparison to PnR, the possibility of removing the colliquated vitreous under the detached retina creates more space for the gas filling and the gentler gas injection would probably cause less shift of the remnant vitreous. Furthermore, the colliquated vitreous removal allows us to avoid the invasive procedure of paracentesis and, even more relevant, it allows us to increase the amount of gas filling, which is important to cover all the cryo-treated areas.

In conclusion, our novel technique resulted in 85% of anatomical success, with a statistically significant improvement of BCVA in macula-off patients. No postoperative complications have been recorded, except for three retinal re-detachments. The main limitations of this study are the small number of patients enrolled, the selection of only uncomplicated RDs and the short follow-up time. Moreover, the lack of patient monitoring during the postoperative follow-up to ensure a strict head position represents another limitation. Indeed, we considered this aspect mandatory. Although further studies are necessary, we believe that our minimal two-port dry vitrectomy could be considered a valid alternative to treat primary RRD, with high efficacy and safety profile.

SUMMARY

What was known before

- The management of many common configurations of RRD remains controversial. The main surgical interventions currently used are scleral buckle (SB), pars plana vitrectomy (PPV), which could be performed alone or combined, and pneumatic retinopexy (PnR).

What this study adds

- The aim of this study was to evaluate the safety and efficacy of a new surgical technique consisting of a dry localized two-port vitrectomy close to the causative retinal break/s and drainage of the subretinal fluid followed by a cryoretinopexy, for the management of RRD.

DATA AVAILABILITY

The datasets analyzed during the current study are available from the corresponding author on reasonable request.

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AUTHOR CONTRIBUTIONS

Study concept and design: EP, TC. Acquisition, analysis, and interpretation of data: LM, MMC, ESP, VC. Drafting of the manuscript: EP, TC, FT, AS. Critical revision of the manuscript: CI and SR. Statistical analysis: FT, AS. Administrative, technical, or material support: ESP, LM. Supervision: EP, TC, SR.

COMPETING INTERESTS

The authors declare no competing interests.

ADDITIONAL INFORMATION

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