• Brief Report •

# Clinical outcomes of management of posterior capsule rupture with air bubble techniques

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## Abstract

● **AIM:** To introduce a new surgical technique, air-bubble technique for the management of posterior capsule rupture (PCR) and to evaluate the safety and efficacy of the technique.

● **METHODS:** A retrospective case series analysis of 24 eyes of 24 patients, in which the air bubble technique was used for the management of PCR, was performed. Once PCR occurred, a dispersive ophthalmic viscosurgical device (OVD) was injected into the tear. And small volumes (0.2-0.3 mL) of air bubbles were injected beneath the OVD. The air bubble served as a physical barrier and supported the posterior capsule.

● **RESULTS:** After surgery, none of the patients had serious complications during the follow-up period of 1y. Extension of the PCR size occurred in only 2 cases, and additional OVD injection was required only in 3 cases. Air bubbles imparted great stability to the nuclear pieces and the posterior capsule.

● **CONCLUSION:** The air-bubble technique may be considered a safe and effective procedure for managing a PCR. It may be of value to the inexperienced cataract surgeon.

● **KEYWORDS:** air bubble technique; posterior capsule rupture; cataract

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## INTRODUCTION

Posterior capsular rupture (PCR) is one of the most common complications during cataract surgery. With reported incidences being up to 7.9%, PCR remains a significant risk factor associated with poor visual outcome[1-3]. Although the rate of PCR is especially higher among novice surgeons, it also happens in the most experienced surgeons[4]. It challenges the skills and clinical judgment of the surgeon to prevent vitreous loss and lens materials sinking through the posterior capsular defect. Also incomplete removal of prolapsed vitreous and incarceration into the section leads to post-operative complications such as retinal detachment, chronic uveitis and cystoid macular edema[1,5-6].

In institutes with vitreoretinal surgeons, pars plana vitrectomy (PPV) might be the first choice of management[7]. However, uncertainty in the need of PPV in cases without obvious dropped lens nucleus, inexperience in vitreoretinal surgical skills (PPV by anterior surgeons), and the inconvenience of referral to a posterior surgeon are still being the reasons for hesitation of performing PPV[8].

The authors have been using a novel PCR management technique (air bubble technique) for more than 5y as one of the therapeutic options for patients with PCR during cataract surgery. The success rate and clinical outcomes after the technique were evaluated. We introduce the new technique and evaluate the efficacy and safety for cataract cases complicated by PCR.

## SUBJECTS AND METHODS

**Ethical Approval** The Institutional Review Board of Dongguk University Gyeongju Hospital approved the retrospective review of the patients' data, and the study adhered to the tenets of the Declaration of Helsinki. Written informed consent was obtained from each patient.

This retrospective, noncomparative, interventional case series analysis encompassed the 24 patients in which the air bubble technique was performed for the management of PCR from April 2012 to December 2015.

Preoperatively, all the patients had a complete ophthalmic examination, including uncorrected visual acuity (UCVA), best corrected visual acuity (BCVA), slit-lamp examination and dilated fundus examination. Patients who had a follow-up with 1y or more were included in this study. The air

bubble technique was performed in cases complicated by intraoperative PCR with a nuclear or cortical remnant yet to be removed.

The surgical procedure was as follows. The air bubble technique was performed by a single surgeon (Lee S). Early recognition of PCR, while performing the cataract surgery was the most important. As soon as the PCR or vitreous loss was noticed, the surgery was stopped. The surgeon avoided immediately withdrawing the phaco tip and filled the anterior chamber with a dispersive ophthalmic viscosurgical device (OVD) such as Viscoat (Alcon, Fort Worth, TX, USA) prior to removing the phaco tip. Also, the OVD was injected beneath lens material through the posterior capsule defect to tamponade the vitreous, sequester lens fragments anteriorly (Figure 1A).

After removing the phaco tip, small volumes of air bubbles (0.2-0.3 mL) were then injected into Berger's space (Figure 1B). Periodic palpation of the globe confirmed that over inflation had not occurred. The air bubbles served as a barrier to isolate the dispersive OVD-filled anterior chamber from the posterior segment of the eye. Also, the bubbles provided immediate supplemental support as artificial posterior capsule to prevent lens material from dropping posteriorly and shield the phaco tip or irrigation/aspiration (I/A) tip from aspirating vitreous from below.

Phaco over the artificial posterior capsule, which is the air bubbles, could avoid converting to a large incision manual extracapsular cataract extraction (ECCE; Figure 2A). Also, bimanual I/A of residual cortex, with lower flow fluidic could be performed without additional injection of OVD to support the posterior capsule (Figure 2B). Usually the anterior chamber must be filled with OVD for the torn posterior capsule not to bulge forward, when the phaco tip or I/A are removed. However, with the air bubbles, working as artificial posterior capsule, additional injection OVD needs not be repeated when removing the instruments.

In case of any trans-pupillary vitreous bands, air bubbles helped visualizing the vitreous band at the air/vitreous interface. With better visualization, anterior vitrectomy could be performed easily, avoiding vitreous traction.

The extent of capsular defect and capsular support was investigated to choose the best site for the intraocular lens (IOL) implantation after nucleus emulsification. Sulcus placement was done in cases with adequate anterior capsular rim and sulcus support. The air bubbles were simply removed using a needle tip before or after the IOL implantation (Figure 3). All patients were reviewed postoperatively and discharged on a routine postoperative regimen (moxifloxacin 0.5% 4 times daily and prednisolone acetate 1.0% 4 times daily).

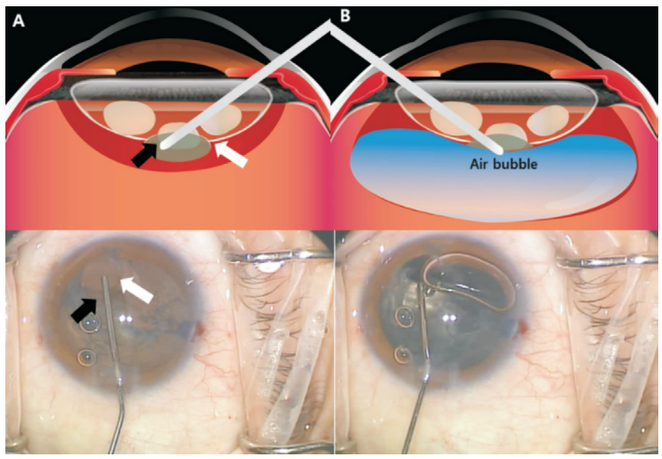


**Figure 1 The air-bubble technique** A: The dispersive ophthalmic viscosurgical device (OVD) is injected beneath the posterior capsule rupture (PCR) site (white arrow, PCR; black arrow, OVD). B: After the OVD is injected, a small volume of air (0.2-0.3 mL) is injected posterior to the tear site and the OVD.

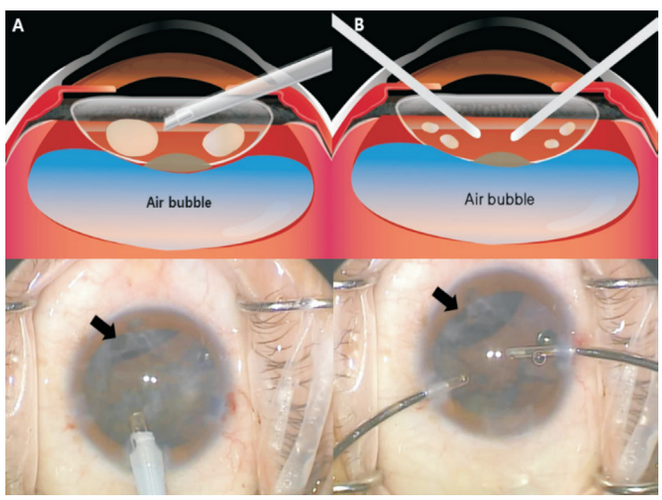


**Figure 2 Phacoemulsification (A) and bimanual irrigation/aspiration (B) using the air-bubble technique** Air bubbles (black arrow) serve as a physical barrier and plug the posterior capsule rupture site during surgery.

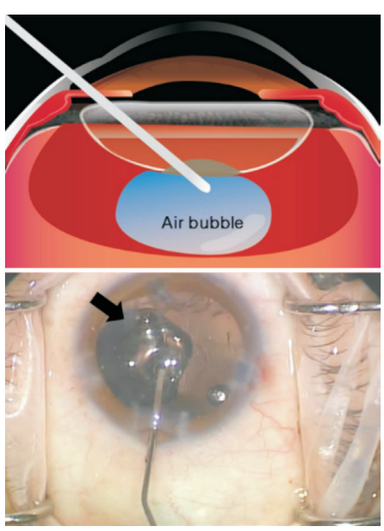


**Figure 3 Removal of the air bubbles** The air bubbles can be simply removed using a needle tip.

## RESULTS

The air-bubble technique was performed in 24 eyes in which PCR occurred during the nuclear phacoemulsification step. All PCR occurred during the cases by beginning novice surgeons. The cases are summarized in Table 1. The mean age of the patients was 71.9±8.7y, consisting of 14 males and 10 females. The PCR developed during cracking nuclear halves in 6 patients (25.0%), during making second half in 8 (33.3%), and during phacoemulsifying the last nuclear fragments in 10 (41.7%).

Anterior vitrectomy was performed in 15 patients (62.5%). In all cases, a 3-piece IOL was implanted in the sulcus, and the final BCVA was better than 20/40. Extension of the PCR size occurred in only two cases, and additional OVD injection was needed in the first three cases. There were no serious complications such as a dropped lens, displaced IOL, retinal detachment, or vitreous incarceration. Postoperative cystoid macular edema was found in one patient and treated using topical non-steroidal anti-inflammatory drugs. The results suggested that the air bubbles imparted greater stability to the nuclear pieces and the posterior capsule when compared with use of the OVD only.

**Table 1 Totally 24 cases of posterior capsule rupture managed with the air-bubble technique**

| Characteristic | No. |
|---|---|
| Patients (eyes) | 24 (24) |
| Mean age±SD, y | 71.9±8.7 |
| Gender (M/F) | 14/10 |
| Stage of posterior capsule rupture | |
| Cracking nuclear halves | 6 (25.0%) |
| Second half | 8 (33.3%) |
| Phacoemulsification of last fragment | 10 (41.7%) |
| Nuclear density (LOCS III Grading) | |
| 2+ | 4 (16.7%) |
| 3+ | 10 (41.7%) |
| 4+ | 7 (29.1%) |
| 5+ | 3 (12.5%) |
| Anterior vitrectomy | |
| Yes | 15 (62.5%) |
| No | 9 (37.5%) |

## DISCUSSION

Advances in instrumentation and techniques have decreased the incidence of PCR[6,9-12]. However, the occurrence of PCR is unavoidable even in the most experienced surgeons. The most important things regarding management of PCR involve avoiding extension of defect size and preventing vitreous loss or nuclear drop[7-8]. Excessive manipulation without early diagnosis of PCR can cause its extension[13]. Prolapse of vitreous causes significant ocular morbidity, such as retinal teat, detachment and cystoid macular edema. Also, incomplete removal of vitreous leads to IOL tile, decentralization and vitreous incarceration in the surgical wounds[8]. And a nuclear drop into the vitreous cavity can induce vitreous inflammation and subsequent macular edema, affecting the vision[13].

A dispersive OVD has been used as an effective barrier to the vitreous prolapse, while preventing posterior dropping of lens material[7-8]. Despite its superiority in space occupying and resistance to flow, the OVD does not usually remain in place during the subsequent surgical procedure. Therefore, repeated injection of OVD is required beneath the capsular defect and into the anterior chamber. It poses the possibility of anterior chamber collapse whenever the surgical instruments are withdrawn from the eye, and vitreous prolapse or nuclear drop, when the OVD was inadvertently aspirated.

Surgeons have used a trimmed Sheets glide to manage PCR for more than 15y[14-15]. Originally developed for the implantation of rigid PMMA IOL, Sheets glide has been also used as a pseudo-posterior capsule to facilitate completion of phacoemulsification of the lens' nucleus following PCR during phaco. It can guide a nuclear fragment out of OVD filled anterior chamber by posterior wound lip pressure during PCR. The use of Sheets glide adopted the concept of inserting an "artificial posterior capsule", being an attractive idea[4].

Recently novel devices for the management of PCR have been developed based on the principle of the Sheets glide[4,13,16-19]. Nevyas-Wallace and Wallace[20] devised an expandable barrier glide. Totally 3 Pivotal curved pieces of the polyethylene glide can be inserted through a 2.5 mm corneal incision and reach a width of 6.25 mm when spread apart. It works occluding the pupillary area, functioning as a pseudo-capsule. Mehta *et al*[17] proposed the use of scrolled up contact lens to be positioned under the nuclear fragments similar to a life buoy. Being pseudo-posterior capsule, the hydroxyethyl methacrylate (HEMA) contact lens allowed phacoemulsification to proceed safely, preventing vitreous prolapse or nuclear fragments drop. Also, an injectable version of the contact lens is being planned. However, the devices including Sheets glide have to be removed after the surgery. The risk of trauma to the adjacent structures and vitreous loss during removing the device exists[4].

The key concept of air-bubble technique is also inserting an "artificial posterior capsule". It has some strengths for several reasons. First, the air bubble forms a mechanical support for remnant nuclear fragments, preventing nuclear drop. When posterior capsule is open, the dispersive OVD injected beneath lens material allows compartmentalization of lens material. The air bubble beneath the OVD can provide supplemental support preventing nuclear descent, even if the OVD is inadvertently aspirated or burped from the Berger's space. Second, the air bubble separates the anterior chamber and

vitreous cavity, keeping vitreous back and preventing further vitreous prolapse and being aspirated into the phaco tip. It also provides a safe platform to perform phacoemulsification or I/A with low fluidic settings. Residual nuclear fragments in the bag can be phacoemulsified safely and efficiently with moderate parameters, with air bubble occluding the posterior capsule. Moderate or large sized fragments, especially if hard cannot be dealt with vitrectomy cutter and usually require nucleus forceps or pediatric vectis when the posterior capsule is open. However, the use of both instruments requires widening the corneal incision, which might become uncontrolled and traumatic to the cornea and iris. Also, the risk of more vitreous to prolapse is increased with a larger incision[4]. The air bubble technique can provide cushioning effect as an automobile airbag. The "air bag cushion" prevents fluid infused into the anterior chamber during phacoemulsification from entering the vitreous cavity, permitting completion of the removal of residual nucleus by phaco with minimizing the risk of capsular tear extension. It can avoid converting to a larger incision manual ECCE. Also, bimanual I/A with lower flow fluidic can be safely and efficiently performed for cortical clean-up.

Once posterior capsule is open, dispersive OVD should be repeatedly injected into anterior chamber through side-port opening, whenever phaco or I/A handpiece is removed[8]. Injection of OVD prior to removal of the handpiece allows minimizing the pressure gradient that develops as the handpiece is withdrawn from the eye, which would otherwise encourage further vitreous prolapse[4]. The air bubble technique can minimize the effect of pressure gradient without additional OVD injection. Of course, the air bubble technique cannot completely eliminate the pressure gradient between the anterior and the posterior segment. When the handpiece is withdrawn from the eye, small amount of OVD, which was previously injected beneath the capsular defect follows the pressure gradient and oozes from the Berger's space. Then the OVD fills the anterior chamber, especially near the capsular defect, preventing the posterior capsule from bulging forward when the incision is unplugged. The remnant OVD and air bubble in the Berger's space works as the artificial posterior capsule for subsequent procedures. In our study, only the first three cases required an additional OVD injection. This is also another advantage of our technique, as it is cost saving, considering the price of dispersive OVD. Although the dispersive OVDs are advantageous in terms of maintaining space and resisting aspiration, it incurs higher costs[20]. It is of great importance to reduce the costs especially in countries where these devices are not easily available and where the cost of the devices is of concern[2,21].

Furthermore, the identification of vitreous strands can become easier with air bubble technique[5]. The balanced salt solution (BSS) has a similar refractive index to that of the vitreous making its visualization difficult. However, the air/vitreous interface facilitates identification of vitreous strands in the anterior chamber and incarcerated into the section[5]. The vitreous strands then may be demonstrated by the introduction of an iris repositor. They can then be removed by hoovering the surface of the iris with the vitrector.

In summary, small volumes of air bubbles beneath the PCR are sufficient to tamponade the vitreous and sequester lens fragments anteriorly and to protect the preserved posterior capsule, even though the OVD is aspirated during surgery. Also, this technique efficiently stabilizes the anterior chamber preventing further vitreous loss with no additional OVD injections. However, for larger tears greater than one-third of the posterior capsule, air bubbles can move towards the anterior chamber. In this case, it is possible to resume the surgery by re-injecting the OVD and air bubbles. The air bubbles can be simply removed by using a needle tip before or after the IOL implantation. Moreover, they would be naturally absorbed in 2-3d without any procedure.

Limitations of the study lie in its retrospective nature. Longer-term follow-up is also limited in our study. Long-term complications with visual significance such as corneal endothelial cell decompensation due to remnant vitreous may occur over years. Therefore, further prospective studies and long-term follow-up studies are needed to confirm the efficacy and efficiency of the air-bubble technique in PCR management.

In conclusion, management of a PCR using the air-bubble technique is safe and effective, with a low percentage of vitreous loss. Compared with the use of the dispersive OVD only, the air-bubble technique provides better compartmentalization of lens material and quarantine of the vitreous. This novel technique may be of value to the inexperienced cataract surgeon.

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