

Ciliary sulcus implantation of intraocular lens in manual small incision cataract surgery complicated by large posterior capsule rupture

JINRONG ZHAO¹, JINGUO YU², TIECHENG WANG³ and BERTIN MBAN⁴

¹Department of Refractive Surgery Centre, Tianjin Eye Hospital, Tianjin 300121;

²Department of Ophthalmology, Tianjin Medical University General Hospital, Tianjin 300052;

³Department of Cataract, Tianjin Medical University Eye Hospital and The College of Optometry and Ophthalmology, Tianjin 300384, P.R. China; ⁴Department of Ophthalmology, Sino-Congo Friendship Hospital,

Brazzaville B.P. 869, Republic of the Congo

Received November 10, 2015; Accepted January 8, 2018

DOI: 10.3892/etm.2018.7074

Abstract. The present study aimed to evaluate the safety and efficiency of ciliary sulcus implantation of intraocular lens (IOL) in patients that had undergone manual small incision cataract surgery (MSICS) complicated by large posterior capsule rupture (LPCR). A total of 11 eyes taken from 11 patients in Brazzaville, Republic of the Congo, that had experienced LPCR following MSICS were included in the current study. A rigid single-piece IOL (5.5 mm optic, 12.50 mm overall length) was implanted into the ciliary sulcus. Postoperative follow-up assessments evaluated visual acuity, anterior segment biomicroscopy, IOL centration and position, and fundus biomicroscopy. The median follow-up time was 3.7 months (range, 2-6 months). All patients experienced vision improvement: Uncorrected visual acuity 2 months following surgery was 0.3-0.5 in 9 patients and >0.5 in 2 patients. Postoperative complications included pronounced anterior segment inflammation (1 patient), mild corneal endothelium edema (3 patients), residual cortex (1 patient) and intraocular pressure elevation (1 patient). Significant IOL decentration and tilt were not observed in any patients. The results of the present study indicate that ciliary sulcus implantation of a rigid single-piece IOL may be a feasible and effective method of treating patients that have experienced LPCR complications following cataract surgery, as it provides satisfactory visual acuity outcomes. Appropriate intraoperative management may reduce the incidence of postoperative complications.

Introduction

Globally, >284 million people are visually impaired, of which 39 million are blind (1). It is estimated that >90% of the world's visually impaired population live in low and middle-income countries. Cataracts are currently the leading cause of avoidable blindness, particularly across Africa (2,3).

Current methods of treating cataracts include conventional extracapsular cataract surgery (ECCE), manual small incision cataract surgery (MSICS) and phacoemulsification (phaco). There are important differences between these different types of cataract surgery: ECCE may lead to surgically induced astigmatism more frequently than the other methods of treatment. Furthermore, the rehabilitation of visual acuity in patients following ECCE is slower and the complication rate is higher compared with that of MSICS and phaco (4-7). However, there is no difference between phaco and MSICS for BCVA, UCVA, endothelial cell loss, intraoperative and postoperative complications (8). However, the use of MSICS is more cost-effective as it avoids the expense of purchasing and maintaining a phaco machine. Therefore, MSICS has been recommended as an acceptable alternative to phaco to treat patients with cataracts in middle- and low-income countries (9,10).

Although cataract surgery is a safe and effective method of restoring sight (11) posterior capsular rupture (PCR) is an inevitable complication that still occurs in all patients that undergo cataract surgery, despite advances in technology (8). PCR not only increases the risk of postoperative cystoid macular edema and retinal detachment and may also require implantation of a posterior chamber intraocular lens (IOL) (12,13). However, primary implantation of IOL in patients following surgery complicated by LPCR is not suitable without adequate capsule and zonular support (14).

Between May 2013 and June 2015, MSICS were performed for 193 patients with age-related cataract at the Sino-Congo Friendship Hospital (Brazzaville, Congo). Of these patients, 11 experienced large PCR (LPCR) following surgery; therefore, primary IOL was implanted into the ciliary sulcus. The

Correspondence to: Dr Jinguo Yu, Department of Ophthalmology, Tianjin Medical University General Hospital, 154 AnShan Road, Tianjin 300052, P.R. China
E-mail: yujg1976@163.com

Key words: cataract, large posterior capsule rupture, intraocular lens, implantation, ciliary sulcus

aim of the present study was to evaluate the safety and efficiency of the primary implantation of IOL in the ciliary sulcus of patients that had experienced LPCR following MSICS.

Patients and methods

Patients. A total of 11 consecutive patients were accepted into the current prospective study. Each patient presented with age-related cataracts and underwent MSICS at the Sino-Congo Friendship Hospital and developed a LPCR with a central posterior capsular rupture size of >5 mm and a normal anterior capsule, or a >120 and <180 degree of peripheral rupture (15). The median age of the patients was 69.8 years old (range, 48-79 years) and there were 7 males and 4 females. Of the 11 patients, 5 experienced LPCR in the right eye and 6 had LPCR in the left eye. The types of cataracts in the patients were as follows: Posterior subcapsular cataract in 1 patient, intumescent cataracts in 2 patients, mature cataracts in 5 patients and hypermature cataracts in 3 patients (Table I). In these cases, the posterior capsular rupture occurred during nucleus removal in 8 patients and during irrigation/aspiration in 3 patients. Furthermore, 10 of the 11 patients exhibited vitreous prolapse. All patients provided informed consent for inclusion in the current study and ethical approval was obtained from the Ethics Committee of Tianjin Medical University Eye Hospital (Tianjin, China).

Surgical procedure. For all patients that underwent MSICS, following adequate mydriasis with tropicamide 0.8% and phenylephrine 5% compound tropicamide eye drops (Shenyang Sinqi Pharmaceutical Co., Ltd., Shenyang, China), local anesthesia was induced using a 2 ml 2% lidocaine hydrochloride injection (Tianjin Pharmaceutical Group Xinzhen Co., Ltd., Zhengzhou, China) via retrobulbar block. The conjunctiva was cut open using scissors along the superior limbus, forming a fornix based conjunctival flap and haemostasis was achieved with cauterization. A 5.5-mm straight scleral incision of partial thickness was made 2 mm behind the corneal limbus. A scleral tunnel was constructed using a crescent knife (Sharpoint™; Surgical Specialties Corporation; Angiotech, Vancouver, Canada) and extended up to 1.0 mm into the clear cornea. Additional paracentesis was made at 10 o'clock position using a paracentesis knife (Sharpoint™; Surgical Specialties Corporation; Angiotech, Vancouver, Canada). Through the paracentesis, viscoelastic materials (Medical sodium hyaluronate gel; Shanghai Qisheng, Biological Preparation Co., Ltd., Shanghai, China) were injected to form the anterior chamber and protect the corneal endothelium. Subsequently, a 3.2-mm keratome (Sharpoint™; Surgical Specialties Corporation; Angiotech) was used to access the anterior chamber and the internal corneal incision was extended up to 10 mm. A continuous curvilinear capsulorhexis (CCC) of 5-6 mm was initiated and completed using a bent 25-gauge needle. If the CCC margin extended to the equatorial part of the lens, the CCC was converted to canopener anterior capsulotomy in 3 patients. Hydrodissection was completed using a 24-gauge cannula. Viscoelastic materials were injected into anterior chamber and 2 Sinsky hooks were introduced via the tunnel incision. The first hook was inserted under the rhexis with the tip pressed gently against the inferior margin of lens nucleus, and the other

hook elevated the superior margin of the lens nucleus and held it. The first hook rotated the nucleus towards the margin of the rhexis continuously until the nucleus prolapsed into the anterior chamber. The prolapsed nucleus was extracted from the eye using a lens loop. The cortex was removed using a simcoe irrigation/aspiration cannula. A rigid single-piece IOL (5.5 mm optic, 12.5 mm overall length; Eyegood Medical, Co., Ltd., Zhuhai, China) was implanted in the capsular bag inflated by viscoelastic materials and its position was adjusted using a lens hook. Posterior capsular rupture may occur during the aforementioned process and patients with LPCR (15) were included in the current study.

Treatment of LPCR. When PCR occurred, the operation was stopped and viscoelastic materials were immediately injected into the capsular bag to tamp the capsule rupture to avoid or minimize the loss of vitreous and nuclei fragments into the vitreous cavity. Any vitreous prolapses in the anterior chamber were completely removed using Mcpherson-Vannas scissors. Cortical remnants were gently cleaned up manually with Simcoe cannula with closing the irrigation fluid (dry absorption method) (16). Following the injection of viscoelastic materials between the iris and potential remaining anterior capsule, the first haptic of IOL was inserted through the 5.5 mm scleral tunnel incision into the ciliary sulcus. The IOL was then rotated horizontally using a lens hook to insert the second haptic into ciliary sulcus, then the lens hook was inserted behind IOL to hold it and adjust its position in order to ensure that the two haptics were well positioned in the ciliary sulcus. Viscoelastic materials were cleaned up using an aspirating cannula and an air bubble was injected via paracentesis into the anterior chamber in order to maintain normal intraocular pressure. The integrity of the self-sealing scleral incision was ensured and conjunctival flap was sutured using two stitches with a 10-0 suture.

Postoperative treatment. Postoperatively, all patients received one drop of topical eye drops, (TobraDex; Shanghai Lilian Information Technology Co., Ltd., Shanghai, China), 4 times a day for 2 weeks. Patients also received one drop of Pranopulin (Senju Pharmaceutical Co., Ltd., Osaka, Japan) 4 times a day for 4 weeks. Follow-up was performed 1 day, 1 week, 2 weeks and 1 month following surgery, and monthly thereafter. The median follow-up time was 3.7 months (range, 2-6 months). At each follow-up visit, visual acuity was monitored and a complete ocular examination was performed using a slit lamp microscope and ophthalmoscopy. Intraocular pressure was examined using a Schiottz tonometer, if required. Each examination evaluated visual acuity, corneal edema, anterior chamber depth and inflammation, posterior synechia of iris, intraocular pressure, lens decentration and tilt, intraocular hemorrhage, cystoid macular edema and retinal detachment.

Results

Visual acuity. In the present study, the International Standard Visual Acuity Chart was adopted to assess visual acuity (17). In this study, uncorrected visual acuity [normal range, ≥ 0.3 (18)] was 0.05-0.3 in 2 patients, 0.3-0.5 in 7 patients and >0.5 in 2 patients, 1 day postoperation. After 1 week, uncorrected

Table I. Demographic characteristics of patients (n=11).

Characteristic	Number of patients
Age, years	
≤50	1
51-65	3
≥65	7
Sex	
Male	7
Female	4
Eye	
Right	5
Left	6
Cataract type	
Posterior subcapsular	1
Intumescent	2
Mature	5
Hypermaturation	3

visual acuity was <0.3 in 1 patient, 0.3-0.5 in 8 patients and >0.5 in 2 patients. At weeks after the operation, uncorrected visual acuity was 0.3-0.5 in 9 patients and >0.5 in 2 patients. At 1 and 2 months postoperation, uncorrected visual acuity remained at 0.3-0.5 in 9 patients and was >0.5 in 2 patients. At the final follow up visit, uncorrected visual acuity was 0.3-0.5 in 9 patients and >0.5 in 2 patients (Table II). Postoperative visual acuity was categorized according to the World Health Organization (WHO) Guidelines (19), as follows: A good outcome (0.3-1.0), a borderline outcome (0.1-0.3) and a poor outcome (<0.1). Therefore, the results indicate that no patients exhibited a poor outcome of visual acuity in the final follow-up assessment.

IOL centration and position. IOL centration was evaluated following pupil dilation with compound tropicamide eye drops. IOL decentration was defined when the optic edge of the 5.5 mm optic diameter IOL was visible through a 4.5 mm diameter pupil as a result of tilt or subluxation >1.0 mm. Postoperatively, IOLs were well positioned in all patients without a clear IOL tilt, decentration or luxation (Table III).

Postoperative complications. A number of complications were observed, including pronounced anterior segment inflammation, observed in 1 patient. This inflammation was reduced within 2 weeks following surgery. Mild corneal endothelium edema (MCEE) was observed in 3 patients immediately following surgery; however 1 week later, corneal stroma edema and bullous keratopathy were no longer observed. Small residual cortex fragments were observed at the back of the peripheral iris in 1 patient, this was not present 1 month following surgery; pupil area in this patient was transparent. Transient elevated intraocular pressure was observed in 1 patient 1 day following surgery, due to the remaining viscoelastic materials. Subsequently, 250 ml 20% mannitol was administered intravenously and intraocular pressure

immediately returned to normal levels. PCR carries a high incidence of various postoperative complications including, chronic intraocular inflammation, CME, IOL dislocation, retinal detachment and endophthalmitis (20). These were not observed in the present study (Table IV).

Discussion

Modern cataract surgery is safe and effective in >95% of patients, but in a small number of cases, intraoperative and postoperative complications may occur (20). These may lead to failure of the IOL implant and potentially vision loss. PCR is a complication that may occur during cataract surgery, despite various technological advances that have improved the safety of such procedures (12). The primary factors leading to PCR include lens dislocation during capsulotomy, a smaller incision for the nucleus expression, high pressure from the posterior chamber, small pupil in the course of cortex aspiration and traction on the capsular bag when removing anterior part of the cortex causing unexpected damage to the posterior capsule (21). Day *et al* (22) demonstrated that PCR and/or vitreous loss occurred in 1.95% of patients that underwent cataract surgery. However, this varies slightly depending on the cataract operation completed; the incidence was 0.27% in femtosecond laser cataract surgery (23), 0.68% in phaco (24), 2.0% in MSICS (25) and 2.9% in ECCE (26).

Although the incidence of PCR is higher in patients that undergo MSICS, it remains the primary method of operating on cataracts in low- and middle-income countries, as it is a more cost effective method of removing cataracts than other procedures, yet still yields good postoperative results (10). Future studies should aim to improve the treatment of PCR and minimize the risks to patients following implantation of an ideal IOL in MSICS.

Following PCR, it is important to establish whether the implantation of a posterior chamber IOL would be suitable. Previous studies have determined that posterior chamber IOL may be implanted successfully in cases involving small PCR (27,28), however, the risks associated with implantation are higher in patients with LPCR (29). Implantation of IOL, regardless of the size of PCR, may cause IOL tilt, dislocation and the misplacement of haptics into the vitreous cavity (17). In such conditions, there are other options for the implantation of IOL, including primary anterior chamber lens implantation and secondary scleral-fixated intraocular lens implantation (30,31).

The present study investigated 11 patients that had developed LPCR following MSICS in Brazzaville, Republic of the Congo that underwent IOL implantation into the scleral sulcus to restore the visual acuity of these patients. The present study assessed the effectiveness of this method with the aim of improving the treatment of patients with cataracts in low- and middle-income countries, such as the Republic of the Congo. A number of reasons, including chronic shortages of medical materials, mean the only feasible method of treating the complications that occur following cataract surgery is IOL. The majority of patients will be unable to undergo second implantation of IOL, as cost and transport duration pose a formidable barrier (32,33). Furthermore, there are often shortages of cataract surgeons, nurses and equipment in low- and

Table II. Visual acuity in patients at each postoperative follow-up assessment (n=11).

Category	Number of patients					
	Day 1	Week 1	Week 2	Month 1	Month 2	Final assessment
0.05-0.3	2	1	0	0	0	0
0.3-0.5	7	8	9	9	9	9
>0.5	2	2	2	2	2	2

Table III. Complications of IOL observed at the last visit time (n=11).

Complication	Number of patients
Decentration of IOL	0
Tilt of IOL	0
Subluxation of IOL	0
IOL, implantation of intraocular lens.	

Table IV. Complications observed on postoperative day 1 (n=11).

Complication	Number of patients
Pronounced anterior segment inflammation	1
Mild corneal endothelium edema	3
Residual cortex	1
Elevated intraocular pressure	1

middle-income countries, and the training of new cataract surgeons is not sufficient to meet demand (33,34). In addition, it is often difficult to access optometric services in such countries, therefore all patients following cataract surgery that are unable to undergo implantation, will experience reduced postoperative visual acuity (35).

To reduce the risk of PCR, the primary objective is the thorough and safe removal of lens fragments and vitreous from the anterior segment, whereas the stable placement of IOL is the secondary objective. It is also important to detect the signs of PCR, which include the sudden deepening of anterior chamber, spontaneous cortical shift, difficulty to remove the remaining nucleus or cortex, abnormal reflection of light by the posterior capsule and vitreous prolapse, as early as possible (20). Following detection of posterior capsular rupture, intraocular surgery should be stopped and viscoelastic materials immediately injected to prevent the expansion of PCR; the vitreous prolapse into the anterior chamber and outside of the eye should be cut off completely using Mcpherson-Vannas scissors and remains of nucleus fragments carefully removed; and the lens cortex should be

aspirated using the dry absorption method (36). The aforementioned procedures should be completed away from the site of PCR. Intraoperative management should prioritize patient safety and aim to stabilize anterior chamber volume, minimize vitreous traction and protect the posterior capsular and zonular from any further damage (37).

Prior to implantation of IOL into the scleral sulcus, viscoelastic materials should be injected into the anterior chamber and pupil to push the prolapsed vitreous into vitreous cavity to separate it from the posterior surface of the iris, thus exposing it to the ciliary sulcus and the remaining posterior capsule (38). The first haptic of IOL should be inserted along the posterior surface of the iris; the optical part should then be rotated horizontally to allow implantation of the second haptic (38). Ensuring the two haptics have been placed into ciliary sulcus, the position of haptic should be adjusted to ensure that at least one haptic is supported by the remaining posterior capsule (39). Viscoelastic materials should be removed using low fluid flow and the anterior-posterior movement of IOL should be observed by assessing the change of anterior chamber depth. If no horizontal shift or tilt is observed, this indicates that the IOL is stable (40). Finally, the injection of an air bubble into the anterior chamber at the end of cataract surgery exhibits no unfavourable effect on the corneal endothelium and as such protects the endothelium (41) to prevent the inflow of ocular surface fluid (42), to protect from leakage of the surgical incision (43) and to reduce anterior chamber inflammation following surgery (44). The present study revealed that the anterior chamber depth and intraocular pressure were well maintained in the majority of patients. Only 1 patient exhibited transient elevated intraocular pressure complications.

In the present study, all patients experienced vision improvement with an uncorrected visual acuity of >0.3 in all patients 2 months onwards following surgery; visual acuity was 0.3-0.5 in 9 patients (81.8%) and >0.5 in 2 patients (18.2%). Wilczyński *et al* (45) demonstrated that the mean postoperative visual acuity of patients in a group that had experienced PCR was 0.63 ± 0.27 ; by contrast, the reference group, who underwent uncomplicated cataract surgery exhibited a postoperative visual acuity of 0.78 ± 0.18 ($P < 0.001$); Patients that had experienced PCR were ~5 times more likely to exhibit a final visual acuity <0.5 compared with patients that had not experienced complications following surgery (45); Furthermore, patients that experience PCR are 2.6 times more likely to develop other early postoperative and intraoperative complications compared with patients that do not experienced complications (45). In the present study, all patients achieved good visual acuity according to the WHO Guidelines at the

final follow-up (ranging from 2 to 6 months; however, due to poor local economic conditions and inconvenient travel, the median follow up time for patients was only 3.7 months. Thus, the visual acuity of patients 6 months postoperation cannot be predicted from the results of the current study.

The present study evaluated the successful implantation of 11 rigid single-piece IOLs into the scleral sulcus into eyes of 11 patients that had undergone MISCS complicated by LPCR. None of the IOLs exhibited signs of decentration during the follow-up period. Rau *et al* (46) used ultrasound biomicroscopy to locate the IOL haptics following implantation in the ciliary sulcus and identified an asymmetry of the haptics positioning in 3 eyes (27.2%) and identified intraocular lens decentration in 2 eyes (18.1%). Sauer *et al* (47) used a Purkinje meter to locate the IOL implanted in the ciliary sulcus and observed that mean horizontal optic tilt was $7.68^{\circ} \pm 5.16$, mean vertical optic tilt was $3.01^{\circ} \pm 2.44$, horizontal decentration was 0.4 ± 0.33 mm and vertical decentration was 0.31 ± 0.21 mm. Due to the lack of equipment and supplies in the poor country of Africa (48) and the lack of an instrument to measure the tilt and decentration of IOL in the hospital, the method used in the present study to judge it is subjective and easily affected by pupil size and shape. However, this simple method was the only ways to judge the IOL position in the current study due to the limited medical equipment available. The current study completely removed the prolapsed vitreous to expose the scleral sulcus by injecting viscoelastic materials between the iris and the remaining anterior capsule. Subsequently, two haptics were placed into the sulcus and an air bubble was injected into the anterior chamber to maintain normal intraocular pressure at the end of the surgery. This enabled the successful implantation of the IOL into the sulcus without inducing tilt and decentration.

Early postoperative complications including pronounced anterior segment inflammation, MCEE, residual cortex and transient intraocular pressure, were temporarily observed in the patients included in the current study. Other complications were not observed during the follow-up time of the current study, including photopsia, pigment dispersion, intraocular hemorrhage, iris transillumination defects and cystoid macular edema (49). Renieri *et al* (28) assessed the eyes of 13 patients with implanted IOL in the sulcus due to complications following phaco, including extensive posterior capsule rupture with or without vitreous loss. Postoperative complications included corneal edema (2 patients), Descemet folds (1 patient), intraocular pressure elevations (3 patients) and pronounced anterior segment inflammation (1 patient). Compared with these results, the present study obtained good results from MSICS, as no severe postoperative complication occurred. Gentle manipulation, appropriate scleral incision, protection of the corneal endothelium using viscoelastic material, complete aspiration of cortex and stable maintenance of intraocular pressure during surgery are able to reduce the risk of postoperative complications occurring in patients following MSCIS.

In conclusion, ciliary sulcus implantation of a rigid single-piece IOL may be a feasible method of treating patients with cataracts that have experienced complications including LPCR and produces satisfactory outcomes regarding visual acuity in patients. Appropriate intraoperative management may also reduce postoperative complications. Therefore,

the current study demonstrates that IOL implantation may be a feasible and effective low-cost method of treating patients following MSICS complicated by LPCR in low- and middle-income countries.

Competing interests

The authors declare that they have no competing interests.

References

1. Pascolini D and Mariotti SP: Global estimates of visual impairment: 2010. *Br J Ophthalmol* 96: 614-618, 2012.
2. Baltussen R and Smith A: Cost effectiveness of strategies to combat vision and hearing loss in sub-Saharan Africa and South East Asia: Mathematical modelling study. *BMJ* 344: e615, 2012.
3. Resnikoff S, Pascolini D, Etya'ale D, Kocur I, Pararajasegaram R, Pokharel GP and Mariotti SP: Global data on visual impairment in the year 2002. *Bull World Health Organ* 82: 844-851, 2004.
4. Kongsap P: Visual outcome of manual small-incision cataract surgery: Comparison of modified Blumenthal and Ruit techniques. *Int J Ophthalmol* 4: 62-65, 2011.
5. Ang M, Evans JR and Mehta JS: Manual small incision cataract surgery (MSICS) with posterior chamber intraocular lens versus extracapsular cataract extraction (ECCE) with posterior chamber intraocular lens for age-related cataract. *Cochrane Database Syst Rev* 18: CD008811, 2014.
6. de Silva SR, Riaz Y and Evans JR: Phacoemulsification with posterior chamber intraocular lens versus extracapsular cataract extraction (ECCE) with posterior chamber intraocular lens for age-related cataract. *Cochrane Database Syst Rev* 29: CD008812, 2014.
7. Haripriya A, Chang DF, Reena M and Shekhar M: Complication rates of phacoemulsification and manual small-incision cataract surgery at Aravind Eye Hospital. *J Cataract Refract Surg* 38: 1360-1369, 2012.
8. Gogate P, Optom JJ, Deshpande S and Naidoo K: Meta-analysis to compare the safety and efficacy of manual small incision cataract surgery and phacoemulsification. *Middle East Afr J Ophthalmol* 22: 362-369, 2015.
9. Jiang T, Jiang J, Zhou Y, Zhao GQ, Li H and Zhao SY: Cataract surgery in aged patients: phacoemulsification or small-incision extracapsular cataract surgery. *Int J Ophthalmol* 4: 513-518, 2011.
10. Jaggernath J, Gogate P, Moodley V and Naidoo KS: Comparison of cataract surgery techniques: Safety, efficacy, and cost-effectiveness. *Eur J Ophthalmol* 24: 520-526, 2014.
11. Baltussen R, Sylla M and Mariotti SP: Cost-effectiveness analysis of cataract surgery: A global and regional analysis. *Bull World Health Organ* 82: 338-345, 2004.
12. Hong AR, Sheybani A and Huang AJ: Intraoperative management of posterior capsular rupture. *Curr Opin Ophthalmol* 26: 16-21, 2015.
13. Chan E, Mahroo OA and Spalton DJ: Complications of cataract surgery. *Clin Exp Optom* 93: 379-389, 2010.
14. Evereklioglu C, Er H, Bekir NA, Borazan M and Zorlu F: Comparison of secondary implantation of flexible open-loop anterior chamber and scleral-fixated posterior chamber intraocular lenses. *J Cataract Refract Surg* 29: 301-308, 2003.
15. Li JJ, Zhao RB and Lin H: Ciliary sulcus sutured intraocular lens and anterior chamber intraocular lens implantation for cataract surgery type of posterior capsule rupture. *Int J Ophthalmol* 3: 535-537, 2010.
16. Wei Li: Efficacy observation of 'dry absorption method' with viscoelastic material in therapy of lens capsule rupture. *Public Medical Forum Magazine* 12: 2468-2469, 2012.
17. Wenbin GU and Lei L: The cause of low vision after phacoemulsification and intraocular lens implantation. *Chin J Ocular Trauma Occupat Eye Dis* 26: 242-244, 2004 (In Chinese).
18. Mpyet C, Dineen BP and Solomon AW: Cataract surgical coverage and barriers to uptake of cataract surgery in leprosy villages of north eastern Nigeria. *Br J Ophthalmol* 89: 936-938, 2005.
19. Venkatesh R, Das M, Prashanth S and Muralikrishnan R: Manual small incision cataract surgery in eyes with white cataracts. *Indian J Ophthalmol* 53: 173-176, 2005.
20. Chakrabarti A and Nazm N: Posterior capsular rent: Prevention and management. *Indian J Ophthalmol* 65: 1359-1369, 2017.

21. Gao Y, Chen T and Zhao S: An analysis of posterior capsular rupture in cataract surgery. *Zhonghua Yan Ke Za Zhi* 32: 200-202, 1996 (In Chinese).
22. Day AC, Donachie PH, Sparrow JM and Johnston RL; Royal College of Ophthalmologists' National Ophthalmology Database: The Royal College of Ophthalmologists' National Ophthalmology database study of cataract surgery: Report 1, visual outcomes and complications. *Eye (Lond)* 29: 552-560, 2015.
23. Chee SP, Yang Y and Ti SE: Clinical outcomes in the first two years of femtosecond laser-assisted cataract surgery. *Am J Ophthalmol* 159: 714-719, 2015.
24. Chen M, Lamattina KC, Patrianakos T and Dwarakanathan S: Complication rate of posterior capsule rupture with vitreous loss during phacoemulsification at a Hawaiian cataract surgical center: A clinical audit. *Clin Ophthalmol* 5: 375-378, 2014.
25. Venkatesh R, Tan CS, Singh GP, Veena K, Krishnan KT and Ravindran RD: Safety and efficacy of manual small incision cataract surgery for brunescant and black cataracts. *Eye (Lond)* 23: 1155-1157, 2009.
26. Signes-Soler I, Javaloy J, Montés-Micó R, Muñoz G and Albarrán-Diego C: Efficacy and safety of mass cataract surgery campaign in a developing country. *Optom Vis Sci* 90: 185-190, 2013.
27. Taskapili M, Engin G, Kaya G, Kucuksahin H, Kocabora MS and Yilmazli C: Single-piece foldable acrylic intraocular lens implantation in the sulcus in eyes with posterior capsule tear during phacoemulsification. *Cataract Refract Surg* 31: 1593-1597, 2005.
28. Renieri G, Herzog D, Niemann S, Becker M, Kurz S and Thieme H: Sulcus implantation of a single-piece foldable acrylic intraocular lens after posterior capsular rupture in cataract surgery. *Eur J Ophthalmol* 22: 950-955, 2012.
29. Mohebbi M, Bashiri SA, Mohammadi SF, Samet B, Ghassemi F, Ashrafi E and Bazvand F: Outcome of single-piece intraocular lens sulcus implantation following posterior capsular rupture during phacoemulsification. *J Ophthalmic Vis Res* 12: 275-280, 2017.
30. Chan TC, Lam JK, Jhanji V and Li EY: Comparison of outcomes of primary anterior chamber versus secondary scleral-fixated intraocular lens implantation in complicated cataract surgeries. *Am J Ophthalmol* 159: 221-226.e2, 2015.
31. Sheludchenko VM, Sheludchenko NV, Éksarenko OV and Poleva RP: Results of intraocular lens implantation on top of the anterior capsule in cases of phaco complications. *Vestn Oftalmol* 130: 42-46, 2014 (In Russian).
32. Ibrahim N, Pozo-Martin F and Gilbert C: Direct non-medical costs double the total direct costs to patients undergoing cataract surgery in Zamfara state, Northern Nigeria: A case series. *BMC Health Serv Res* 15: 163, 2015.
33. Eliah E, Lewallen S, Kalua K, Courtright P, Gichangi M and Bassett K: Task shifting for cataract surgery in eastern Africa: Productivity and attrition of non-physician cataract surgeons in Kenya, Malawi and Tanzania. *Hum Resour Health* 12 (Suppl 1): S4, 2014.
34. Palmer JJ, Chinanayi F, Gilbert A, Pillay D, Fox S, Jaggernath J, Naidoo K, Graham R, Patel D and Blanchet K: Trends and implications for achieving VISION 2020 human resources for eye health targets in 16 countries of sub-Saharan Africa by the year 2020. *Hum Resour Health* 15: 45, 2014.
35. Palmer JJ, Chinanayi F, Gilbert A, Pillay D, Fox S, Jaggernath J, Naidoo K, Graham R, Patel D and Blanchet K: Mapping human resources for eye health in 21 countries of sub-Saharan Africa: Current progress towards VISION 2020. *Hum Resour Health* 15: 12: 44, 2014.
36. Songpin YK: Application of static aspiration on posterior capsular rupture in phacoemulsification. *J Clin Ophthalmol* 19: 290-291, 2001.
37. Qian D and Lin Z: Primary IOL implantation in rupture of posterior capsule in cataract extraction. *Chin J Ocular Trauma Occupat Eye Dis* 23: 63-64, 2001 (In Chinese).
38. Hui C, Qiu X and Huang X: Clinical observation of posterior chamber intraocular lens implantation in the large ruptured mouth of posterior capsule. *Chin J Traum Occupat Eye Dis* 34: 680-682, 2012 (In Chinese).
39. Hongjian Z, Xia X and Ji W: Clear cornea phacoemulsification and intraocular lenses implantation in posterior capsule rupture. *Rec Adv Ophthalmol* 20: 212-213, 2000.
40. Suhua Z: Clinical analysis of intraocular lens implantation in scleral sulcus. *J Med Forum* 27: 35-39, 2006.
41. Norn MS: Corneal thickness after cataract extraction with air in the anterior chamber. *Acta Ophthalmol (Copenh)* 53: 747-750, 1975.
42. Sim DA, Wong R and Griffiths MF: Injecting an air bubble at the end of sutureless cataract surgery to prevent inflow of ocular surface fluid. *Eye (Lond)* 21: 1444-1445, 2007.
43. Agarwal T, Singh D, Khokhar S and Panda A: Simple technique for sealing clear corneal wound leaks using a dynamic anterior chamber air bubble. *J Cataract Refract Surg* 37: 1732, 2011.
44. Demirci G, Karabas L, Maral H, Ozdek S and Güllükilic G: Effect of air bubble on inflammation after cataract surgery in rabbit eyes. *Indian J Ophthalmol* 61: 343-348, 2013.
45. Wilczyński M, Wilczyńska O, Synder A and Omulecki W: Incidence and functional outcome of phacoemulsification complicated by posterior capsular rupture. *Klin Oczna* 111: 26-29, 2009.
46. Rau R, Santana CR, Martinez AA, Silva AL and Allemann N: Positioning of intraocular lens haptics intentionally implanted in the ciliary sulcus by ultrasound biomicroscopy. *Arq Bras Oftalmol* 76: 147-151, 2013 (In Portuguese).
47. Sauer T and Mester U: Tilt and decentration of an intraocular lens implanted in the ciliary sulcus after capsular bag defect during cataract surgery. *Graefes Arch Clin Exp Ophthalmol* 251: 89-93, 2013.
48. du Toit R, Faal HB, Etya'ale D, Wiafe B, Mason I, Graham R, Bush S, Mathenge W and Courtright P: Evidence for integrating eye health into primary health care in Africa: A health systems strengthening approach. *BMC Health Serv Res* 13: 102, 2013.
49. Chang DF, Masket S, Miller KM, Braga-Mele R, Little BC, Mamalis N, Oetting TA and Packer M; ASCRS Cataract Clinical Committee: Complications of sulcus placement of single-piece acrylic intraocular lenses: Recommendations for backup IOL implantation following posterior capsular rupture. *J Cataract Refract Surg* 35: 1445-1458, 2009.