

# Black diaphragm intraocular lens implantation and penetrating keratoplasty in aphakic eyes with traumatic aniridia

Jun Li<sup>1,2</sup>, Xiao-Guang Dong<sup>2</sup>

<sup>1</sup>Qingdao University Medical College, Qingdao 266071, Shandong Province, China

<sup>2</sup> Shandong Eye Institute, Shandong Academy of Medical Sciences, Qingdao 266071, Shandong Province, China

**Correspondence to:** Xiao-Guang Dong. Shandong Eye Institute, 5 Yanerdao Road, Qingdao 266071, Shandong Province, China. dxgdoctor@hotmail.com

Received: 2013-03-05

Accepted: 2013-04-01

## Abstract

• **AIM:** To evaluate the long-term outcome of implantation of black diaphragm intraocular (BDI) lens combined with penetrating keratoplasty (PKP) for managing aphakic eyes with traumatic aniridia and corneal damage.

• **METHODS:** Six aphakic eyes of six patients with traumatic aniridia and corneal damage had BDI lens implantation at Qingdao Eye Hospital, Shandong Eye Institute from June 2008 to November 2011. Medical records of the patients were reviewed. Three patients received PKP and after 12–18 months were implanted with BDI lens. The other three patients completed PKP and BDI lens implantation at the same time. The corrected visual acuity, intraocular pressure and number of corneal endothelial cells were monitored.

• **RESULTS:** The patients were followed up for an average of 24.3±12.1 months (range 14–48 months). All BDI lenses were located well. The best corrected visual acuity got improved in 5 patients (0.1–1.0) and decreased in 1 patient from 0.4 to 0.2. Three patients had normal intraocular pressure (IOP) after implantation. Two patients required antiglaucoma medications to control IOP within the normal range and 1 patient implanted Ahmed glaucoma valve to control IOP. The corneal grafts kept transparent in all eyes and the corneal endothelial counting >1 000/mm<sup>2</sup>, although two patients experienced acute graft rejection and loss more than 30% corneal endothelial cells.

• **CONCLUSION:** Implantation of BDI lens combined with PKP is an effective option for managing aphakic eyes with traumatic aniridia and corneal damage. Although the results in our study are encouraging, additional studies of the long-term safety and efficacy are required. A

larger study population and longer follow-up may be beneficial.

• **KEYWORDS:** black diaphragm intraocular lens; penetrating keratoplasty; aniridia; trauma

**DOI:10.3980/j.issn.2222-3959.2013.02.15**

Li J, Dong XG. Black diaphragm intraocular lens implantation and penetrating keratoplasty in aphakic eyes with traumatic aniridia. *Int J Ophthalmol* 2013;6(2):183–186

## INTRODUCTION

Severe traumatic rupture of the globe often results in corneal laceration, aniridia, lens opacity or dislocation, vitreous hemorrhage, and retinal detachment, which are usually treated by combined corneal cracking suturing, lens extraction, pars plana vitrectomy, and retinal reattachment to keep the eyeball complete and restore some visual functions. However, due to spherical aberration and chromatic dispersion caused by defects in the iris, photophobia, glare, and visual dysfunction often occur after surgery. The black diaphragm intraocular (BDI) lens is a special type designed to meet the needs of patients with aniridia or severe iris defects<sup>[1]</sup>. But some of the patients had severe corneal scar at the center of cornea, or corneal edema and bullous keratopathy. A single intraocular lens (IOL) implantation cannot correct visual acuity, and combined penetrating keratoplasty (PKP) is needed to remove scar and cloudiness and improve eyesight.

Good clinical effects of BDI lens implantation in eyes with aniridia and aphakia have been reported<sup>[2-5]</sup>, including elimination of photophobia, good cosmetic effect of the appearance of the eye, and correction of ametropia with the transparent central optical area. We followed up some patients who received PKP and BDI lens implantation, expecting to evaluate the long-term effects of this surgical treatment.

## SUBJECTS AND METHODS

This study was approved by the Institutional Review Board of Shandong Eye Institute. Six eyes of six patients received PKP and BDI lens implantation surgery for traumatic aniridia at Qingdao Eye Hospital, Shandong Eye Institute from June 2008 to November 2011. They were all male, with a mean

**Table 1 Traumatic aniridia patients' data before black diaphragm intraocular lens implantation.**

No.	Sex	Age (a)	Original ocular problem	Visual acuity		IOP	Cornea status	Endothelial cell density (/mm <sup>2</sup> )	Lens status	Duration from PKP to implantation (months)
				Uncorrected	Best corrected					
1	M	25	Rupture	0.1	0.4	Normal	Graft transparent	1718		14
2	M	10	Penetrating injury	0.05	0.6	Normal	Graft transparent	1945		18
3	M	9	Intraocular foreign body injury	0.02	0.3	Normal	Graft transparent	2352		12
4	M	35	Penetrating injury	FC/BE	FC/BE	Normal with travoprost	Cornea edema	Uncountable	Aphakic	/
5	M	44	Rupture	FC/30cm	FC/30cm	Normal	Cornea edema	Uncountable		/
6	M	35	Rupture	0.02	0.02	Normal	Cornea edema	Uncountable		/

M: Male; FC: Finger counting; BE: Before eye.

age of 26.6 years (range 9-44 years) at surgery. The iris was defected due to ocular trauma in all eyes, in combination with corneal damage, traumatic aphakia or cataract, and vitreous hemorrhage. Rupture suture, cataract extraction, and vitrectomy had been performed in these patients prior to PKP and BDI lens implantation.

Preoperatively, best corrected visual acuity (BCVA) and intraocular pressure (IOP) were examined. A slit-lamp anterior segment evaluation, fundus examination, and corneal endothelial cell density were carried out. The preoperative ophthalmic history and findings are shown in Table 1. According to the patients' surgery, they could be divided into two groups. One group did PKP first and then implanted the BDI lens, another group completed two parts at the same time. The inclusion criteria for the patients were as follows: BCVA  $\geq$  0.3 and CEC density  $\geq$  1 500/mm<sup>2</sup> (for the patients who had got PKP). The visual evoked potential examination (VEP) revealed that the optic nerve function was good (for the patients who hadn't got PKP). IOP was examined to be within the normal range with or without intervention. No tractional retinal detachment or anterior proliferative vitreoretinopathy was found by fundusscopes, B-ultrasonography and ultrasound biomicroscopic (UBM).

Informed consent was obtained from all patients before the implantation of a black diaphragm poly (methyl methacrylate) (PMMA) IOL (67B and 67G, Morcher, GmbH, Stuttgart, Germany) with an overall length of 12.5mm. Each end of the C-shaped haptics had an eyelet for suture fixation. The 10.0-mm optic presented a 3.0-mm (67B) or 5.0-mm (67G) clear central zone surrounded by a peripheral diaphragm of black PMMA.

One surgeon (X.D.) performed all surgery. Three patients (patients 1-3) were treated by PKP [6] firstly and implanted with BDI lens after 12-18 months. An infusion port for IOP regulation was inserted and fixed inferotemporally through the pars plana 4.0mm posterior to the limbus. A scleral tunnel, 11.0mm long and 4.0mm wide, was made without penetrating the eye just posterior to the superior limbus.

After a triangular scleral flap was prepared at 6 o'clock for covering the suture for IOL fixation, a 10-0 polypropylene double-arm suture was passed into the anterior chamber under the 12 o'clock scleral flap and pulled out under the 6 o'clock scleral flap, both 2mm posterior to the limbus. Then a 3.2-mm keratome was used ~~via~~ the superior scleral tunnel. The suture was retrieved through the superior limbal incision before cut in the middle, and the cut ends were secured to the respective eyelet. The superior scleral tunnel was sutured after IOL insertion. The other three patients completed PKP and BDI lens implantation at the same time. The scleral tunnel was not needed in the process, and the BDI lens was inserted through the penetrating hole for keratoplasty in the center of the cornea.

## RESULTS

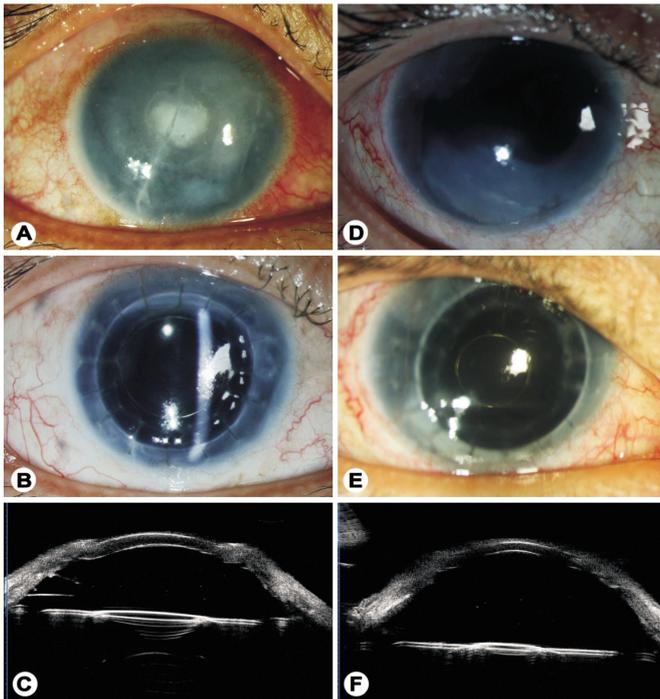
All surgeries were completed uneventfully. Photophobia disappeared in all eyes. Mild anterior chamber inflammatory reaction subsided within 1 month after IOL implantation. Good visual acuity was achieved, and the best corrected visual acuity (BCVA) got improved in all eyes. Because these eyes had irregular astigmatism due to corneal transplants, postoperative visual improvement was affected. Patient 4 was treated with RGP at 3 months after surgery, and the corrected visual acuity reached 0.8, which was better than 0.3 with glasses.

Patients 2 and 6 required antiglaucoma medications to control IOP within the normal range for 6 months after surgery. The IOP of patient 5 was uncontrolled with eyedrops of timolol, brinzolamide, brimonidine and travoprost in about 1 month, after which an Ahmed glaucoma valve was implanted to decrease the elevated pressure. During the follow-up period of 14-48 months, no severe complications were observed. The corneal grafts kept transparent in all eyes, although two patients experienced acute graft rejection and loss many corneal endothelial cells (Table 2). The ultrasound biomicroscopic examination showed the BDI lens was located well in the ciliary sulcus. There was no shift of the lens, and the haptics did not contact with the cornea (Figure 1).

**Table 2 Patients' results after BDI lens implantation**

No.	Follow-up period (months)	Type of BDI	Visual acuity		IOP	Endothelial cell density (/mm <sup>2</sup> )
			Uncorrected	Best corrected		
1	48	67G	0.1	0.2	Normal	1074
2	30	67B	0.3	1.0	Normal with brinzolamide	<sup>1</sup> 1964; <sup>2</sup> 1239
3	24	67B	0.3	0.6	Normal	1862
4	15	67G	0.2	0.3	Normal	2676
5	14	67B	0.1	0.5	Normal with Ahmed valve	<sup>1</sup> 1777; <sup>2</sup> 1191
6	15	67B	0.05	0.1	Normal with timolol	1600

<sup>1</sup>Before corneal graft rejection; <sup>2</sup>After corneal graft rejection.



**Figure 1 The condition of the eyes before and after PKP and BDI lens implantation** (Patient 4: A, B and C. Patient 6: D, E and F) A and D: There are corneal opacity and edema before surgery; B and E: The corneal grafts keep transparent after surgery; C and F: UBM showed the BDI lens was located well in the ciliary sulcus.

## DISCUSSION

Traumatic aniridia is one of the common complications after eyeball rupture. Some patients may have their partial visual function preserved, but suffer from photophobia and glare. The BDI lens has been widely used around the world for 20 years for correction of visual acuity and elimination of photophobia. Because of severe corneal scar and corneal edema, the vision cannot be improved by simply implanting BDI lens to correct the refractive state. Therefore, PKP becomes a necessary step to restore the transparency of refractive medium and the visual function.

Because PKP and BDI lens implantation are both sophisticated surgery, it's very important to choose a suitable patient. In addition to a good corrected vision, the condition of retina is a key point, and it would be very difficult to recover retinal detachment with a BDI lens in the eye. The

patients must be confirmed that there was no retinal detachment or anterior proliferative vitreoretinopathy before implantation and re-examined under the artificial cornea in surgery. If there was traction or detachment, BDI lens can't be implanted. Our patients had taken vitrectomy before, so prolapse of vitreous and traction to retina wouldn't happen when the IOL was implanted. For the eyes with vitreous body, the vitreous must be cut completely before implantation and the surgeon need to avoid make any artificial hole to retina. Ozbek *et al*<sup>[7]</sup> also suggest that proper management of the accompanying vitreoretinal problems in aphakic and aniridia eyes should be done before black diaphragm IOL implantation. They even prefer to place a buckle before PPV even if a retinal detachment is not detected.

In previous clinical observations<sup>[8]</sup>, we found that the long-term complications were related to the preoperative degree of damage to the anterior chamber angle and iris defects, as well as the implanted BDI lens. The BDI lens is larger and heavier than the regular lens, which makes it difficult to fix the IOL stably just with the support from the two suspension sutures. The contact of its edge with the anterior chamber angle and cornea may cause chronic irritation to the trabecular meshwork and peripheral cornea, resulting in chronic damage to the blood-aqueous barrier and the corneal endothelial cell loss, particularly in eyes with aniridia which lose the blocking effect of iris to the lens.

In the previous implant surgery<sup>[5]</sup>, the suspension needle was inserted at 1.5mm after the limbus, but in these patients, the distance was increased to 2mm. We believed that the backward shift of the IOL position can reduce the friction opportunities between the IOL and chamber angle tissue. Patients 1 and 3 had about 1mm wide iris tissue remained. Patients 4 and 5 had complete lens capsules which were resected in the center during surgery, while the IOL was implanted after the capsular ring was retained. The remnant iris and capsule played the blocking role for BDI lens. For patients 2 and 6, the iris and capsule were completely missing, so we added two sutures before BDI lens during surgery to produce a barrier.

The function of sodium pump in corneal endothelial cells is important to maintain the transparency of cornea. Owing to the lack of reproductive activity in endothelial cells, functional decompensation would occur when excessive loss of endothelial cells was caused by any injury, and could lead to corneal edema and opacity. This also might happen to the endothelium of corneal graft after PKP<sup>[9,10]</sup>. Although the influence caused by BDI lens to the cornea reduced, acute graft rejection occurred in patients 2 and 5 at about half a year after surgery. After treatment in time, corneal edema regressed and corrected visual acuity recovered, but the number of corneal endothelial cells significantly reduced. There were many risk factors that can directly and indirectly injure the endothelium of grafts. Rejection was the highest among all factors and most endothelial decompensation occurred within 2 years, which may be related to early rejection<sup>[11]</sup>. Therefore, our patients need long-term observation and anti-rejection treatment.

Traumatic aniridia is often accompanied by substantial damage in the anterior segment. Elevated IOP becomes the most common postoperative complication after implantation of BDI lens<sup>[3, 5, 8, 12-14]</sup>. Reinhard *et al*<sup>[15]</sup> found about 65% of the identifiable haptics were not found in the ciliary sulcus but in the angle of the anterior chamber. It may be attributable to the direct compression from the haptics to the trabecular meshwork<sup>[15,16]</sup>. Half of our patients (3/6) suffered IOP increase, and they could be controlled by medicine or Ahmed glaucoma valve. The proportion of secondary glaucoma in this series did not exceed the previous reports.

In summary, implantation of BDI lens combined with PKP is an effective option for managing aphakic eyes with traumatic aniridia and corneal damage. Although the results in our study are encouraging, additional studies of the long-term safety and efficacy are required. A larger study population and longer follow-up may be beneficial.

**REFERENCES**

1 Sundmacher R, Reinhard T, Althaus C. Black-diaphragm intraocular lens for correction of aniridia. *Ophthalmic Surg*1994;25(3):180-185  
 2 Thompson CG, Fawzy K, Bryce IG, Noble BA. Implantation of a black

diaphragm intraocular lens for traumatic aniridia. *J Cataract Refract Surg* 1999;25(6):808-813  
 3 Beltrame G, Salvat ML, Chizzolini M, Driussi GB, Busatto P, Di Giorgio G, Barosco F, Scuderi B. Implantation of a black diaphragm intraocular lens in ten cases of post-traumatic aniridia. *Eur J Ophthalmol* 2003;13(1): 62-68  
 4 Chen YJ, Wu PC. Favorable outcome using a black diaphragm intraocular lens for traumatic aniridia with total iridectomy. *J Cataract Refract Surg* 2003;29(12):2455-2457  
 5 Dong X, Yu B, Xie L. Black diaphragm intraocular lens implantation in aphakic eyes with traumatic aniridia and previous pars plana vitrectomy. *J Cataract Refract Surg*2003;29(11):2168-2173  
 6 Xie L. *Corneal Transplantation* 2000. Beijing. People's Medical Publishing House. 296-300  
 7 Ozbek Z, Kaynak S, Zengin O. Transscleral fixation of a black diaphragm intraocular lens in severely traumatized eyes requiring vitreoretinal surgery. *J Cataract Refract Surg* 2007;33(8):1494-1498  
 8 Dong X, Xu H, Yu B, Ying L, Xie L. Long-term outcome of black diaphragm intraocular lens implantation in traumatic aniridia. *Br J Ophthalmol* 2010;94(4):456-459  
 9 Bourne WM, O'Fallon WM. Endothelial cell loss during penetrating keratoplasty. *Am J Ophthalmol*1978;85(6):760-766  
 10 Price MO, Thompson RW, Price FW. Risk factors for various causes of failure in initial corneal grafts. *Arch Ophthalmol*2003;121(8):1087-1092  
 11 Xiao X, Xie L. The influencing factors and characteristics of corneal graft endothelial decompensation after penetrating keratoplasty. *Eur J Ophthalmol* 2010;20(1):21-28  
 12 Omulecki W, Synder A. Pars plana vitrectomy and transscleral fixation of black diaphragm intraocular lens for the management of traumatic aniridia. *Ophthalmic Surg Lasers* 2002;33(5):357-361  
 13 Lanzagorta-Aresti A, Menezo-Rozalen JL, Martinez-Costa R, Cisneros-Lanuza A. Ahmed valve for elevated intraocular pressure associated with black diaphragm lenses for aniridia. *Eur J Ophthalmol* 2007;17(3):437-440  
 14 Moghimi S, Riazi EM, Maghsoudipour M. Visual function after implantation of aniridia intraocular lens for traumatic aniridia in vitrectomized eye. *Eur J Ophthalmol* 2007;17(4):660-665  
 15 Reinhard T, Engelhardt S, Sundmacher R. Black diaphragm aniridia intraocular lens for congenital aniridia: long-term follow-up. *J Cataract Refract Surg*2000;26(3): 375-381  
 16 Aslam SA, Wong SC, Ficker LA, MacLaren RE. Implantation of the black diaphragm intraocular lens in congenital and traumatic aniridia. *Ophthalmology* 2008;115(10):1705-1712