·Clinical Research·

Long-term results of clear lens extraction combined with piggyback intraocular lens implantation to correct high hyperopia

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Abstract

• AIM: To assess the refractive outcome of clear lensectomy combined with piggyback intraocular lens implantation in highly hyperopic patients.

• METHODS: This case review included 19 eyes of 10 patients with high hyperopia and axial length less than 21mm. Intraocular lens power was calculated for emmetropia using the Holladay II formula in 17 eyes, and SRK/T formula in 2 eyes following clear lens extraction and piggyback intraocular lens implantation. Patients were examined periodically over 24 months for visual acuity and spherical equivalent (SE).

• RESULTS: The mean postoperative SE at 24 months was 0.20 ±1.39D (range, -3.00 to 2.50D), better than preoperative 9.81±2.62D (range, +6.00 to +14.50D) (*P*<0.001). Five eyes had SE within ±0.5D of emmetropia and 11 eyes within ±1.00D at postoperative 24 months. The mean postoperative uncorrected visual acuity (UCVA) at 24 months was 0.60 ±0.36, significantly improved compared to preoperative 1.39±0.33 (*P*<0.001). The mean best-corrected visual acuity (BCVA) at 24 months was 0.49 ±0.35, not statistically different compared to preoperative 0.38±0.30 (*P*=0.34). Twelve eyes maintained and 1 gained 1 or more Snellen line of BCVA, 4 eyes lost 1 line, and 2 eyes lost 2 lines at 24 postoperative months. Twelve eyes best-corrected near visual acuity (BCNVA) achieved J1 at postoperative 24 months compared to preoperative 7 eyes and the other 7 eyes better than J3.

• CONCLUSION: Clear lens extraction combined piggyback intraocular lens implantation appears to be an effective procedure to correct high hyperopia but mild overcorrection and intralenticular opacification may require secondary procedure.

• KEYWORDS: piggyback; intraocular lens; high hyperopia
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INTRODUCTION

Surgical procedures that correct hyperopia include keratophakia, hexagonal keratotomy, automated lamellar keratoplasty, thermal karatoplasty, photorefractive keratectomy (PRK), and laser *in situ* keratomileusis (LASIK). Poor predictability and instability can limit the visual outcome of hyperopic refactive surgery, especially in highly hyperopic short eyes [1,2]. Clear lens extraction (CLE) with intraocular lens (IOL) implantation is an emerging alternative treatment for these cases, especially for aging presbyopic patients, whom lose their accommodation and are totally dependent on optical correction for both near and distance vision [3-6]. Recently the use of novel IOLs, such as the accommodating, multifocal, and aspheric lenses, may improve patient satisfaction. LASIK remains the predominant procedure for the correction of low and moderate hyperopia up to about +3.00D, whereas clear lens exchange plus intraocular lens implantation is preferred for high level of hyperopia above the +3.00D range based on the less compelling postoperative result of LASIK or PRK.

Piggyback IOL implantation was first described in 1993 for correcting extreme hyperopia in a nanophthalmic eye undergoing cataract surgery; two plano-convex IOLs were implanted back to back, the first in the capsular bag (plano side facing anteriorly) and the second in the ciliary sulcus (plano side facing posteriorly) [7]. As the development of the IOL technique, high hyperopia (up to +10.0D) could be corrected with a single aspheic IOL. According to the previous study, foldable piggyback IOLs can provide better optical quality with less spherical aberration than a single high powered IOL. Dual IOLs may also be able to increase the depth of focus by mutual compression of the central optical zone of the implants. This technique could improve the postoperative vision quality by positioning the two lens properly to achieve the desired effect. The efficacy of using multiple lenses has been demonstrated in several studies after CLE or cataract removal for hyperopic patients [8,9]. However, controversy still remains regarding the exact positioning and the type of lenses implanted and the long term effect is variable[10].

We present the clinical outcome of a case series of the refractive clear lens extraction combined with piggyback IOL implantation in the highly hyperopic patients with short eyes and evaluated the efficacy, safety, and predictability of this procedure following 2 years visit according to the standardized format for reporting refractive surgery results as described by Koch *et al* [11].

SUBJECTS AND METHODS

Subjects This retrospective study comprised 19 eyes of 10 patients with hyperopia of 6 diopter or more and ocular axial length less than 21mm who underwent lensectomy between March 2002 and October 2008. The mean age of these 4 men and 6 women was 45.3±7.86 years (range 32 to 55 years). All patients were informed about the surgical procedure and possible complications and provided written consent. Ethical approval for piggyback IOL implantation was approved by the institution. The intended postoperative refraction was emmetropia in all eyes.

Methods Preoperative evaluation included slit lamp evaluation, refractive error examination, fundus examination, Goldman tonometry, keratometry, and corneal endothelial cell count. Axial length and anterior chamber depth were measured by Accuracy and Standard Dimensions (ABD) ultrasound biometry. Intraocular lens power was calculated using the Holladay II formula for 17 eyes and using SRK/T formula for two eyes.

Phacoemulsification was performed through a clear corneal incision under topical anesthesia. A 3.2mm-wide clear corneal incision was made with paracentesis. Nucleofraction phacoemulsification was done with a 5.5mm diameter continuous curvilinear capsulorhexis. Bi-manual aspiration/irrigation was used for eyes with a soft nucleus. After aspiration of cortical material the foldable piggyback IOLs (AcrySof SA60AT, MA60BM, or MA30BM, Alcon, Fort Worth, Texas, USA) were implanted. The first IOL (18.00 to 30.00D) was implanted in the capsular bag, and the second IOL (7.00 to 25.00D) was placed in the capsular bag (11 eyes) or ciliary sulcus (8 eyes). The surgeon chose to implant the second IOL in the bag or in the sulcus depends on eye condition, such as the strength of the ciliary zonule of crystal lens, IOL model, and IOL's position after the second IOL implanted. The second IOL was preferred to be implanted into the bag combined with the first IOL which was single piece IOL SA60AT.

All patients were examined on the first postoperative day and the topical steroid and antibiotics were used. Distance visual acuity including uncorrected visual acuity (UCVA) and best-corrected visual acuity (BCVA), near visual acuity, and spherical equivalent (SE) were evaluated at every follow-up visit.

Statistical Analysis Visual acuity data were converted to logMAR values for analysis, and the mean with standard deviations of measurements were calculated. Statistical evaluation was by the Wilcoxon signed rank test. Difference with a P value less than 0.05 was considered statistically significant.

RESULTS

There is no complication occurred during the surgical procedure. According to the eye condition of each patient the surgeon implanted the second IOL in the capsular bag or ciliary sulcus (Table 1).

Preoperative mean distance UCVA and BCVA were 1.39±0.33logMAR (range, 0.70 to 2.00) and 0.38±0.30logMAR (range, 0.05 to 0.82) respectively. The preoperative mean SE of these patients was 9.81±2.62 (range, 6.00 to 14.50D). The mean preoperative endothelial cell count was 2 462.82±314.14 cells/mm^2 (range, 1 937 to 3 039 cells/mm^2). The mean axial length was 18.57±1.70mm (range, 16.00 to 20.86mm), and the mean depth of anterior chamber of all eyes was 2.67±0.30mm (range, 2.16 to 3.43mm). All 19 eyes completed at least 24 months of follow-up, and the longest follow-up was about 7 years.

Efficacy Piggyback IOLs implantation improved UCVA of all patients (Figure 1). The efficacy index-ratio of mean postoperative UCVA to mean preoperative BCVA was 0.67, 0.72, 0.65, 0.65, and 0.60 at 3, 6, 12, 18, and 24 postoperative months. The mean postoperative UCVA (logMAR) in 6, 12, 18 and 24 months were 0.54±0.34, 0.62±0.37, 0.62±0.36 and 0.60±0.36, and all improved compared to preoperative UCVA (P<0.001). Eighteen (94.74%) of nineteen eyes of best-corrected near visual acuity (BCNVA) were better than J3 and during postoperative 6 months it improved to 100%, but it retracted at postoperative 24 months. There were twelve (63.16%) of nineteen eyes at post-operative 24 months were J1 comparing to preoperative

Table 1 Preoperative axial length, anterior chamber depth, the diopters, the model and the position of the IOLs implanted in all patients

Patient	Gender	Age (a)	Eye	AL (mm)	AC (mm)	IOL power (D)	IOL positions	IOL model
1	M	47	OD	20.2	2.35	+30D/+7D	Bag/sulcus	MA60BM/MA60BM
			OS	20.18	2.54	+30D/+9D	Bag/sulcus	MA60BM/MA60BM
2	F	55	OD	19.45	2.76	+30D/+7D	Bag/sulcus	MA60BM/MA60BM
			OS	19.43	2.46	+30D/+8D	Bag/sulcus	MA60BM/MA60BM
3	M	32	OD	16.38	2.94	+30D/+20.5D	Bag/sulcus	MA60BM/MA60BM
			OS	16.34	2.81	+30D/+21D	Bag/sulcus	MA60BM/MA60BM
4	F	47	OD	19.18	2.65	+30D/+10D	Bag/sulcus	MA60BM/MA60BM
			OS	19.15	2.42	+30D/+10D	Bag/sulcus	MA60BM/MA60BM
5	F	37	OD	16.43	2.68	+30D/+22D	Bag/bag	SA60AT/MA60BM
			OS	16.38	2.72	+30D/+25D	Bag/bag	SA60AT/MA60BM
6	M	40	OD	20.86	3.43	+20D/+13D	Bag/bag	MA60BM/MA60BM
7	F	55	OD	20.59	2.54	+24.5D/+9D	Bag/bag	MA60BM/MA60BM
			OS	20.01	2.16	+18D/+18D	Bag/bag	MA60BM/MA60BM
8	F	54	OD	19.24	2.39	+20D/+23.5D	Bag/bag	MA60BM/MA60BM
			OS	18.87	2.42	+20D/+25D	Bag/bag	MA60BM/MA60BM
9	M	42	OD	16.00	3.15	+30D/+24.5D	Bag/bag	SA60AT/MA60BM
			OS	16.04	2.77	+30D/+22D	Bag/bag	MA60BM/MA60BM
10	F	44	OD	19.03	2.69	+30D/+10D	Bag/bag	SA60AT/MA60BM
			OS	19.00	2.91	+30D/+10D	Bag/bag	SA60AT/MA60BM

OD: Right eye; OI: Left eye; AL: Axial length; AC: Anterior chamber; D: Diopter; IOL: Intraocular lens.

seven eyes (36.84%), thirteen eyes (68.42%) preoperative and fifteen eyes (78.95%) postoperative BCNVA were better than J2 (Figure 2).

Safety The safety index-ratio of mean postoperative BCVA to mean preoperative BCVA was 0.96, 0.92, 0.97, 0.97, 0.80, and 0.84 at 1 month, 3, 6, 12 and 24 months after surgery. The mean BCVA were 0.40±0.31, 0.42±0.35, 0.50±0.32 and 0.49 ±0.35 at 6, 12, 18 and 24 months after surgery, all increased but no statistically significant different (P=0.91, 0.71, 0.29, 0.34) (Figure 3). Twelve eyes maintained and 1 gained 1 or more Snellen line of BCVA, 4 eyes lost 1 line, and 2 eyes lost 2 lines at 24 postoperative months BCVA of twelve of nineteen eyes (63.16%) maintained and 1 eye (5.26%)gained 1 or more lines in Snellen visual acuity and four eyes (21.05%) lost 1 line at 24 postoperative months. Two eyes (10.53%) lost 2 Snellen lines in their BCVA, which were from a glaucoma patient who had a visual field loss before surgery (Figure 4).

Predictability The mean postoperative SE in 6, 12, 18, and 24 months were -0.21 ±1.25D, 0.00 ±1.23D, -0.34 ±1.49D, -0.20 ±1.39D. The preoperative mean spherical equivalent (SE) was 9.81±2.62D, all were better than before surgery (P<0.001). Also we compared the achieved SE to the intended SE at postoperative 24 months; our data showed the predictability of this procedure in most patients was overcorrection (Figure 5). SE of all the patients decreased after the surgery. SE of six eyes (31.58%) are within ±0.5D of emmetropia, thirteen eyes (68.42%) are within ±1.0D, 16

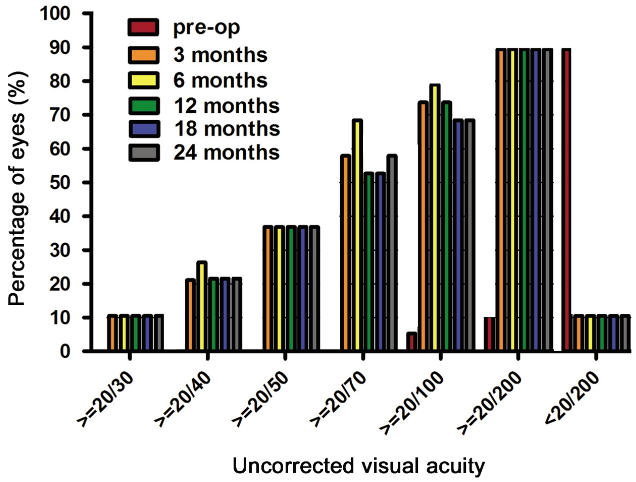

Figure 1 Percentage of the eyes with UCVA ⩾20/200 before and after surgery at 3, 6, 12, 18 and 24 months.

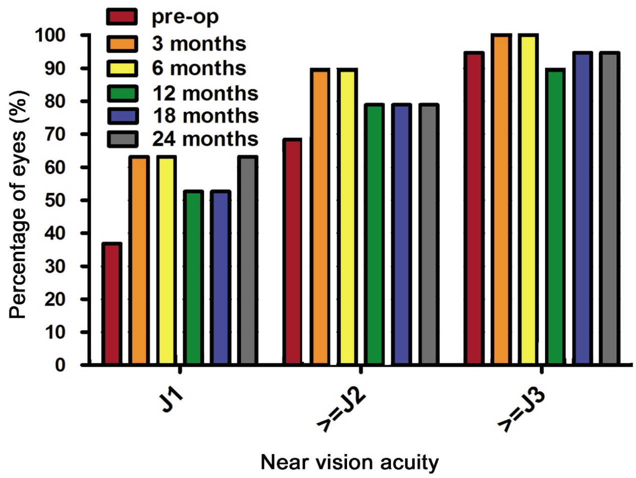

Figure 2 Percentage of the eyes with BCNVA ⩾J3 before and after surgery at 3, 6, 12, 18 and 24 months.

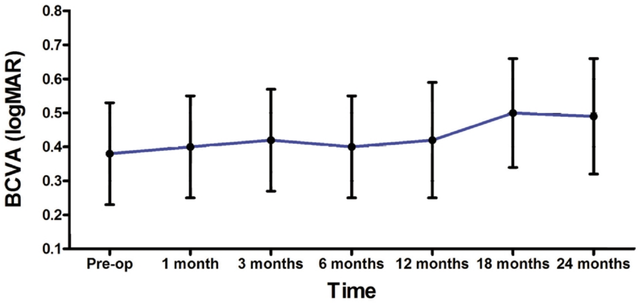

Figure 3 Change of BCVA (logMAR) before and after surgery. Error bar=1/2 SD.

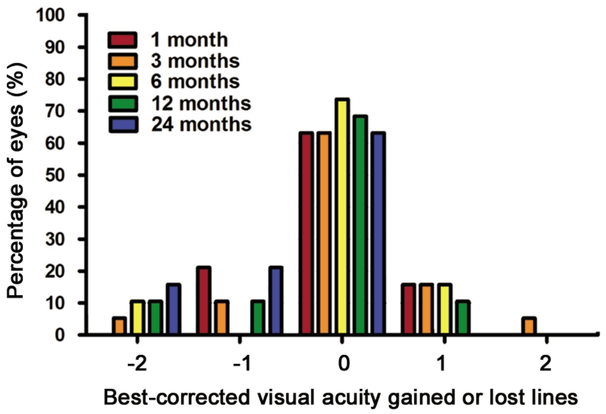

Figure 4 Lost or gain lines of BCVA (logMAR) after surgery.

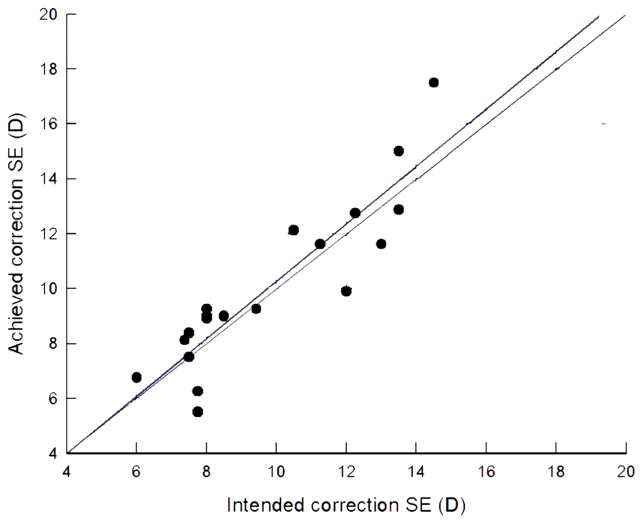

Figure 5 Achieved correction versus intended change in SE of all eyes at the 24 months follow-up. The linear regression line (blue line, r^2=0.81) shows a tendency toward overcorrection.

eyes (84.21%) are within ±1.5D and 17 eyes (89.47%) are within ±2.0D at postoperative12 months. SE of five eyes (26.32) are the within ±0.5D of emmetropia, 11 eyes (57.89%) within ±1.00D, 15 eyes (78.95%) are within ±1.5D and 16 eyes (84.21%) are within ±2.0D at postoperative 24 months.

Stability Figure 6 shows the stability of the SE refraction (P>0.05 between each postoperative interval). Comparing postoperative SE at 12 months to 24 months, nine of nineteen eyes (47.37%) were with change in SE>0.5D and the maximal change was 2.25D hyperopic shift.

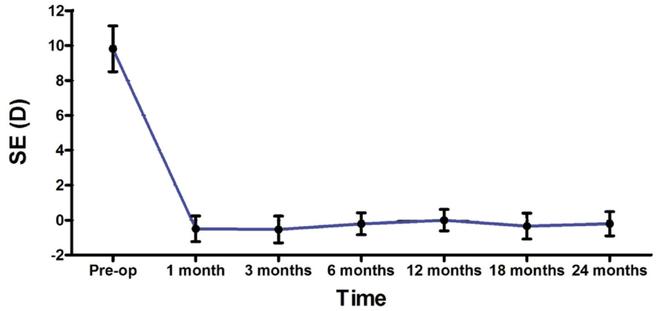

Figure 6 Change of SE in all eyes during the complete 24 months following-up. Error bar =1/2 SD.

Postoperative Complications/Secondary Surgery One patient was performed LASIK in both eyes at 4 months to correct the postoperative myopia. Two eyes developed post-capsular opacification (PCO) at postoperative 12 and 18 months but were successfully treated by neodymium: YAG laser. During 24 months after piggyback surgery no eye was found inter-lenticular opacification (ILO), but there were 3 patients (6 eyes) developed ILO after 3 years post-piggyback surgery.

With more than 24 months following-up one patient (OD) was also performed LASIK to enhance to treat residual hyperopic at post-piggyback surgery 3 years and BCVA was 0.9 after LASIK surgery even though there was pericentral ILO in form of Elschnig pearls at the latest visit. The other two eyes developed ILO, one of them was treated successfully with neodymium: YAG (Nd: YAG) capsulotomy the other eye failed and we suggested the later patient to change the IOL but she refused. We did not found ILO in one patient during 24 months following-up but pigmental opacification appeared at postoperative four-year visit and changed to febrile mass opacification at 7 years after surgery.

DISCUSSION

CLE with IOL implantation is proposed as a safe and effective procedure for patients with nanophthalmos and for hyperopic patients 35 years or older[12,13]. In our study, all eyes were high hyperopic and had a short axial length (<21.0mm), including six with nanophthalmos (axial length <18.0mm). These hyperopic eyes were with a smaller axial length, small anterior chamber, and small corneal diameters.

IOL calculation and selection is difficult in high hyperopia because most IOL power formulas are not accurate in their predictions [14]. To overcome this problem we preferred Holladay II formula to calculate the IOL power because previous reports showed that this method is more accurate than other formulas. Achieved SE approximates predicted SE using the Holladay Consultant formula for IOL power calculation. The Lloyd Gills regression formula with modifiers gives as good results as Holladay II but it creates more under corrections and over corrections. Our predictability showed overcorrected at 24 months after surgery and compare postoperative SE at 12 months to 24 months, nine of nineteen eyes (47.37%) were with change in SE>0.5D and the maximal change was 2.25D hyperopic shift which was reported related to interlenticular pseudophakic opacification and other reasons[15,16].

Hyperopic eyes are more prone to intraoperative and postoperative complications such as uveal effusion, retinal detachment, intraocular hemorrhage, and glaucoma because of their small anterior and posterior segment. Foldable piggyback IOLs were used in all eyes. Eleven eyes were implanted 2 IOLs in capsule and 8 eyes were implanted one IOL in the bag the other IOL in the ciliary sulcus. No intraoperative complications such as capsule rupture occurred in our series. We did not find rotation, decentration, or tilt on biomicroscopy.

Shugar and Keeler [17] reported primary AcrySof piggyback IOLs had low PCO rate, we have 2 eyes developed PCO postoperatively; the mean time to opacification was 15 months. Both of two eyes had succeeful Nd: YAG capsulotomy with no complications such as cystoid macular edema (CME) or retinal detachment. No eyes developed ILO in our study during 24 months following-up even though it is the most common complication of piggyback implantation. Several studies reported the ILO after piggybacking acrylic intraocular lenses. The true incidence is not known, as it tends to occur more than 1 year after surgery. Gayton *et al*[16] have reported an incidence of 43% in 30 eyes with acrylic IOL sand 22% in 31 eyes with polymethylmethacrylate (PMMA) lens followed for at least 2 years. The exact mechanism of ILO is not clearly elucidated, but it is theorized that the acrylic IOLs may form a seal in front of the anterior capsular edge as well as along the posterior surface of the back lens [18]. As a result, lens epithelial cells may migrate directly into the interlenticular space. ILO may be associated with hyperopic shift and Spencer reported ILO induced a hyperopic shift of 3D in a patient 18 months after surgery. To help resolve this hyperopic shift, Gayton *et al*[19] reported the use of neodymium: YAG laser. Removal of interlenticular opacities is a challenging process. Elschnig pearl-type material can be easily removed from the interface. However, membrane-type opacities, which can be stripped surgically from the PMMA IOLs without difficulty, are very adherent to the AcrySof IOLs necessitating lens exchange[17,20]. Explantation of AcrySof IOLs can be difficult owing to the adherence to the anterior capsule. Creation of a large corneal or limbal wound and removal of the IOLs can avoid the more consuming time and traumatic intraocular separation or division of the lenses.

Previous study reported hyperopic eyes with shallow anterior chambers are more prone to angle closure [21-23]. In a case of report of Iwase, postoperative IOP elevated in secondary piggyback IOLs implantation without history of glaucoma or ocular hypertension [24]. Kolahdouz-Isfahani *et al* [13] recommended peripheral surgical iridectomies in all eyes with an axial length less than 20.0mm. We did not find any eye develop high IOP including one patient who had glaucoma and performed laser peripheral iridectomies in both eyes before surgery.

As patients approach presbyopic age, moderate and high hyperopia increasingly bothersome. The perceived accelerated onset of presbyopia occurs because some accomodation is expended in an effort to clarify distance vision. Many hyperopia patients have significant chronic accommmodation spasm. If the amount of hyperopia is beyond the range of alternative refractive procedures, clear lens extraction with IOL insertion might be the only available surgical option. Overall, our results showed good predictability, safety, efficacy and stability of piggyback IOL implantation to treat hyperopic short eye.

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