Influences of anterior capsule polishing on effective lens position after cataract surgery: a randomized controlled trial

Yang Gao1*, Guang-Fu Dang1*, Xu Wang1, Lian Duan1, Xin-Yi Wu2

1Department of Ophthalmology, Qianfoshan Hospital, Shandong University, Jinan, Shandong Province, China; 2Department of Ophthalmology, Qilu Hospital, Shandong University, Jinan, Shandong Province, China. *Equal contributors.

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Abstract: To evaluate the effects of anterior capsule polishing on effective lens position (ELP) and the actual axial movements of IOLs by measuring the anterior chamber depth (ACD). This prospective randomized double-blind controlled clinical trial included patients who underwent bilateral uneventful cataract surgeries and were implanted the same IOLs (SN60WF). Extensive polishing was performed randomly in the anterior capsule of one eye with Whitman Shepherd double-ended capsule polisher, and the opposite unpolished capsule was used as the control. The ACD was measured 1 day, 1 week, 1 month, 3 months and 6 months after surgery with the anterior segment optical coherence tomography (AS-OCT). The actual axial movement of IOL was defined as the root mean square (RMS) of the change in ELP at each visit. A total of 40 eyes of 20 patients were included, and 10 patients (50%) were men. All the patients underwent uneventful surgeries without intraoperative or postoperative complications, and returned on time for measurements. The mean age of them was 70.5±7.6 years (range 56 to 79 years). No significant differences were observed between the mean ELP of the control group and the polished group (P>0.05). Nevertheless, the ELP_{RMS} of the polished group was significantly smaller than that of the control group (P=0.005). Polishing anterior capsule intraoperatively improved the axial position stability of the IOL in the long term.

Keywords: Age related cataract, phacoemulsification, anterior capsule polishing, optical coherence tomography, anterior chamber depth

Introduction

With the development of surgical techniques and various refraction-correcting intraocular lenses (IOLs), phacoemulsification with foldable IOLs implantation has been referred to as refractive surgery. Accuracy of predicting postoperative refraction is of great importance. Despite of more precise biometry techniques and IOL power calculation formula, postoperative refractive shift can be noticed in some patients. Effective lens position (ELP) of an IOL with a given power determines postoperative refraction. The variations of ELP measured with anterior chamber depth (ACD) result in refractive error change after surgery [1]. Frontward motion of the IOL from the ELP leads to myopia, while rearward movement from the ELP causes hyperopia. The change of ELP reflects the interaction between capsule bag fusion and the fibrotic reaction of the capsule [2]. Residual lens epithelial cells (LEC) after surgery play a major role in the pathogenesis of capsule contraction and fibrosis [3, 4]. Therefore, we hypothesized that LECs removal by anterior capsule polishing could reduce the axial optic movement and the change of ELP.

The limitation of comparing mean ELP is that forward and backward movements are neutralized partly. Eom et al [5] reported that ELP_{RMS} could assess the axial position stability of IOLs more accurately than mean ELP. Therefore we applied ELP_{RMS} to study the impacts of anterior capsule polishing on axial position stability of IOLs. In this clinical study, we operated bilateral phacoemulsification implanted with the Acrysof IQ SN60WF (Alcon Inc.), polished anterior cap-
sule in one eye randomly, and measured ACD, refractive error and uncorrected vision acuity in 6 months after surgery. Therefore, the study was designed to determine the axial position stability of the IOLs after cataract surgery with anterior capsule polishing.

Materials and methods

Patients

We recruited 20 patients (40 eyes) in this prospective clinical trial from January 2013 to January 2014. The research was performed at the ophthalmology department of Qianfoshan Hospital affiliated to Shandong University in Shandong Province. All research and measurements followed the tenets of the Declaration of Helsinki, and the protocol was reviewed and approved by the Ethics Committee of Qianfoshan Hospital (Approval Number: 2012S128). Informed consents from all patients were obtained before the research. Inclusion criteria were bilateral age-related cataract with good overall physical constitution, and uneventful surgeries of both eyes with in-the-bag IOL implantation. Exclusion criteria included history of intraocular surgery or laser therapy, history of ocular trauma or ocular disease, high myopia, diabetes, severe fundus pathology and patients who could not return on time.

Surgical procedure

Patients recruited underwent necessary chemical tests and physical examination. IOL power was decided to obtain postoperative refraction at around -0.50 diopter (D) with SRK/T, HOLLDAY 1 and Haigis formula. Preoperative best-corrected visual acuity (BCVA) was recorded and converted to the logMAR scale. ACD was measured with Visante anterior segment optical coherence tomography (AS-OCT) (Carl Zeiss Meditec) one day before surgery. Three days before surgery, all patients were treated with bilateral Levofloxacin Eye Drops 0.5% (Cravit) four times per day.

Half an hour before surgery, patients were treated with tropicamide phenylephrine eye drops 0.5% (Mydrin-P) twice in 5 minutes to maximize pupil dilation. All surgeries were operated with 2.2 mm co-axial micro-incision (torsional model, Infiniti phaco machine, Alcon, Inc.) by the same surgeon (Guangfu Dang). After topical anesthesia with proxymetacaine eye drops 0.5% (Alcaine), a 2.2 mm clear corneal incision was made at the steep meridian. A soft shell technique was used to protect corneal endothelium and maintain anterior chamber space. A centered circular continuous capsulorhexis (CCC) of 5.5 mm diameter was done with capsulorhexis forceps. Thereafter, thorough hydrodissection was performed to rotate the nucleus freely, and then stop-chop method was used to emulsification and remove the nucleus. The surgeon remained masked for the procedure to be performed until completing cortex aspiration. Polishing anterior capsule in one eye was chosen randomly, and the other not as the control. Randomization method was Biased Coin Design. This procedure was performed using Whitman Shepherd Double-Ended Capsule Polisher (Bausch & Lomb) with the help of red light reaction after the capsular bag was filled with sodium hyaluronate 1% (Healon). The LECs of the anterior capsule and the equatorial LECs were removed with the circular ends of the polisher through the cornea incision. The double-end design with a left angle and a right angle allowed for 180 degrees of cleaning respectively. Afterwards, the dispersed LECs in Healon were cleaned with aspiration. An Acrysof IQ SN60WF was implanted in the bag. Patients were treated with Levofloxacin Eye Drops 0.5% and prednisolond acetate ophthalmic suspension 1% (Pred Fortoo) 4 times a day after surgery for 2 weeks. The interval between bilateral cataract surgeries of each patient was less than 1 month.

Optical coherence tomography

ACD was measured 1 day before surgery as well as 1 day, 1 week, 1 month, 3 months and 6 months postoperatively using AS-OCT. AS-OCT provided high resolution cross-sectional tomograms of ocular structures in the anterior segment without contacting the eye. The measurements and images analyses were performed by the same technician. Patients and the technician remained masked for polishing or not until the end of the study.
Anterior capsule polishing and effective lens position

Table 1. Preoperative data of patients

<table>
<thead>
<tr>
<th>Group</th>
<th>Eyes</th>
<th>BCVA</th>
<th>ACD (mm)</th>
<th>IOL power (D)</th>
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<td><em>P</em> value</td>
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Data are reported as mean values and standard deviation. Statistical analysis was performed with SPSS for Windows (version 17.0, SPSS Inc.). Normality of data distribution was assessed using the Kolmogorov-Smirnov test. For bilateral comparison that showed normal distribution, the paired *t* test was used. For nonparametric data, the Mann-Whitney U test was applied. A repeated measures analysis of variance was used to compare differences among different visits. SNK-q post hoc testing was used to determine if there was a difference. Pearson correlation coefficient was calculated to analyze the relationship between the change of ELP and refraction error change. A *P* value less than 0.05 was considered statistically significant.

Results

A total of 40 eyes of 20 patients were included, and 10 patients (50%) were men. All the patients underwent uneventful surgeries without intraoperative or postoperative complications, and returned on time for measurements. The mean age of them was 70.5±7.6 years (range 56 to 79 years).

Table 1 showed preoperative data of patients including BCVA, ACD, IOL power, and predicted refraction of both groups. There were no statistically significant differences in these characteristics between the control and the polished group (*P>*0.05).

Figure 1 showed that mean ELP among different visits of the polished group was more stable than that of the control group. There were no significant differences of mean ELP among different visits in both groups (control: *F*=0.19, *P*=0.94; polished: *F*=0.08, *P*=0.99), and no significant differences were observed between mean ELP of the control group and the polished group (*P>*0.05). However, the ELP\textsubscript{RMS} of the polished group was smaller than that of the control group during the postoperative 6 months (*P*=0.005) (Table 2).

**Statistical analysis**

Visual acuity and refractive error

The uncorrected visual acuity (UCVA) recorded in logMAR units, and auto refraction (TOPCON RM-8800, Topcon, Corp.) were performed at each visit. Spherical equivalent refraction (SER) (sphere + cylinder/2) was used in subsequent calculations.

**Figure 1**. The mean ELP among different visits in both groups. A showed that means ELP among different visits of the polished group was more stable than that of the control group.

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The uncorrected visual acuity of the control group was 0.07±0.10 at 1 day, 0.08±0.09 at 1 week, 0.09±0.10 at 1 month, 0.10±0.12 at 3 months, and 0.10±0.11 at 6 months postoperatively. The uncorrected visual acuity of the polished group was 0.07±0.09 at 1 day, 0.08±0.09 at 1 week, 0.08±0.09 at 1 month, 0.10±0.08 at 3 months, and 0.10±0.08 at 6 months postoperatively. The values of both groups did not change significantly at each time point (control: F=0.260, P=0.903; polished: F=0.534, P=0.711), and no significant differences were observed between the control group and the polished group (1 day: P=0.87; 1 week: P=0.84; 1 month: P=0.73; 3 months: P=0.89; 6 months: P=0.87).

The refractive error in the control group was -0.33±0.18 D at 1 day, -0.42±0.26 D at 1 week, -0.37±0.24 D at 1 month, -0.36±0.23 D at 3 months, and -0.41±0.22 D at 6 months postoperatively. For the polished group, the refractive error was -0.45±0.18 D at 1 day, -0.53±0.44 D at 1 week, -0.46±0.47 D at 1 month, -0.48±0.22 D at 3 months, and -0.48±0.21 D at 6 months after surgery. The values of both groups did not change significantly at each time point (control: F=0.474, P=0.754; polished: F=0.391, P=0.815), and no significant differences were observed between the control group and the polished group (1 day: P=0.06; 1 week P=0.19; 1 month P=0.25; 3 months: P=0.07; 6 months: P=0.32).

There was a positive correlation between change of mean ELP and postoperative refraction change ($r=0.60, P<0.001$).

**Discussion**

ELP reflecting final longitudinal position of the optic has a clinically relevant impart on postoperative refraction and uncorrected vision acuity. Forward movement of IOL away from retina leads to myopia, while backward movement toward retina causes hyperopia. Thus, minimizing change of ELP is of increasing importance in modern cataract surgery especially when a refraction-correcting IOL is implanted [6, 7]. The axial position shift is closely related to capsular bag fusion, the fibrotic reaction of the capsular bag and the mechanical characteristics of IOL such as design and material [2, 8]. Residual lens epithelial cells after cataract extraction and IOL implantation play a major role in the pathogenesis of capsule contraction and fibrosis [3, 4, 9]. Therefore, this study was designed to determine the impacts of LECs removal by anterior capsule polishing on ELP as well as UCVA and refraction.

<table>
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<tr>
<th>Group</th>
<th>Mean ELP (mm)</th>
<th>ELP$_{RMS}$ (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 day</td>
<td>1 week</td>
</tr>
<tr>
<td>Control</td>
<td>3.97±0.27</td>
<td>3.93±0.25</td>
</tr>
<tr>
<td>Polished</td>
<td>4.02±0.32</td>
<td>3.99±0.29</td>
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*Statistically significant after correction for multiple testing (a=0.05, paired t test).
Anterior capsule polishing and effective lens position

Metaplastic LECs contain lots of α-smooth muscle actin elements which result in anterior capsule contraction such as ACO and capsulorhexis opening constriction. Anterior LECs also migrate to posterior capsule and lead to fibrotic PCO as well as posterior capsule wrinkling [4]. The constriction of anterior and posterior capsule gives rise to axial movement of the IOL-capsule complex [3]. Therefore, the axial position of IOLs was more stable after LECs underneath the anterior capsule and the equatorial LECs were mostly removed with Whitman Shepherd Double-Ended Capsule Polisher. Liu et al [15] found that anterior capsule polishing did not decrease residual cell growth and, conversely, enhanced cell proliferation in capsular bag cultures in their in vitro study. However LECs in vivo might present different cell behavior. Thus further study is needed to figure out whether anterior capsule polishing is beneficial to decrease the growth and proliferation of LECs.

In our study, IQ displayed little axial shift as well as stable refraction error and UCVA throughout the follow-up. This finding agrees with those in previous studies indicating that one-piece hydrophobic acrylic foldable IOL showed little axial movement associated with stable refraction postoperatively [5, 18-20]. The reason may be that hydrophobic acrylic has bioadhesive characteristics improving adhesion of IOL to capsular bag, and thus results in less LECs proliferation and metaplasia on anterior capsule and posterior capsule with consecutive decay of capsule constriction and optic movement [21-23].

Several methods aim to completely eliminate the LECs from the lens capsular bag using drugs, neodymium: YAG and pulse fluid [24-26]. However, all these methods have not been used in human. In our research, we removed LECs intraoperatively with Whitman Shepherd Double-Ended Capsule Polisher which was available for widespread use in ophthalmology. The double ended design with a left angle and right angle on one handle is convenient for surgeon to operate and provides 360-degress polishing. The circular ends are able to clean the equator of the capsular bag and the anterior capsule without hurting the delicate structures of the zonular insertions and the ciliary processes. In our research, no intraoperative or postoperative complications were noticed.

There are limitations to this study. First, the sample was relatively small. Second, no statistically significant differences of postoperative vision acuity and refraction error were observed between the control group and the polished group with IQ implantation. The increase of axial position stability by polishing anterior capsule might not be subjectively noticed for patients implanted with IQ, but may be crucial in refractive cataract surgery which requires an extremely high-level surgical accuracy. Larger study populations with variety of refraction-correcting IOLs are needed to prove this aspect.

In this prospective randomized controlled trial, we polished anterior capsule and equator of the capsule with Whitman Shepherd Double-Ended Capsule Polisher to study the effects on actual axial movement of IOLs. We found that anterior capsule polishing with this instrument improved the axial position stability of SN60WF. Moreover, this IOL displayed little axial shift as well as stable refraction error and uncorrected visual acuity, and no significant differences of postoperative vision acuity and refraction error were observed between the two groups. With the development various refraction-correcting IOLs, axial position stability of IOLs is of increasing importance. Thus, anterior capsule polishing may be considered as an interesting choice, especially in cases with refraction-correcting IOLs implantation.

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Disclosure of conflict of interest

None.

Address correspondence to: Dr. Xin-Yi Wu, Department of Ophthalmology, Qilu Hospital, Shandong University, 107 Wenhua Xi Road, Jinan 250012, Shandong Province, China. Tel: +86 543 89268587; E-mail: wuxyqilu@126.com
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