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# Comparison of posterior capsule folds following intracapsular implantation of three types of intraocular lenses with different haptic design

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## Abstract

**• AIM: To compare the incidence of posterior capsule folds among different types of intraocular lens (IOL) to determine risk factors of posterior capsule folds.**

**• METHODS: It was a retrospective study. We collected the cases in which the patients underwent phacoemulsification (PHACO) and IOL implantation and at least one of the three types of IOL was implanted, including 2-haptic 3-piece IOLs (HOYA PY60AD), 4-haptic 1-piece IOLs (Bausch&Lomb AO), 2-haptic 1-piece IOLs (AMO Tecnis ZCB00). The posterior capsule folds were measured using slit lamp microscope 2d after the surgery. Information of patient's age, gender, length of ocular axis, intraocular pressure, types of IOL were recorded. Posterior capsule fold risk indicators were identified by using logistic regression analysis.**

**• RESULTS: One hundred eighty-seven patients (242 eyes) had been collected, including 80 eyes implanted with HOYA PY60AD IOLs, 81 eyes implanted with Bausch&Lomb AO IOLs, 81 eyes implanted with AMO Tecnis ZCB00 IOLs. The incidence of posterior capsule folds of patients implanted with HOYA PY60AD IOLs was significantly higher than those of patients implanted with AMO Tecnis ZCB00 IOLs. While the incidence of patients implanted with Bausch&Lomb AO IOLs was significantly lower than those of patients implanted with AMO Tecnis ZCB00 IOLs. Multi-factor logistics regression analysis demonstrated that independent risk factors were type of IOLs and length of ocular axis. Compared with AMO Tecnis ZCB00 IOLs, using HOYA PY60AD IOLs increased the risk of posterior capsule folds [*P*=0.020, *OR* (95%CI)=2.145 (1.129, 4.073)], while using Bausch&Lomb AO IOLs reduced the risk [*P*=0.001, *OR* (95%CI)=0.274 (0.127, 0.591)]. Shorter ocular axis might increase the risk of posterior capsule folds [*P*=0.012, OR (95%CI)=0.669 (0.489, 0.915)].**

**• CONCLUSION: Haptic design should be an important consideration in IOL design. Compared with AMO Tecnis ZCB00 IOLs, using HOYA PY60AD IOLs is more likely to lead to posterior capsule folds formation, while using Bausch&Lomb AO IOLs is less likely to lead the formation. The posterior capsule folds are more engendered in eyes with shorter ocular axis.**

**• KEYWORDS:** posterior capsule folds; intraocular lens; haptic design; ocular axis

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## INTRODUCTION

Currently, phacoemulsification with intraocular lens (IOL) implantation is the mainstream treatment of cataract, one characteristic of which is to retain the posterior capsule[1]. Over the past decades, continuous evolution and refined accuracy in cataract surgery has led to increased expectations of patients[2]. In long-term clinical work, we found a phenomenon frequently that folds formed on the posterior capsule membrane in cataract patients postoperatively. The posterior capsule folds usually pass through the central area of the pupil, which formed as a single or several straight line and led to unevenness on posterior capsule. Previously studies have found Nd:YAG laser release incision of posterior capsular folds can significantly improve the visual acuity[3-4], indicating that posterior capsular folds have direct impact on postoperative visual acuity in cataract patients. Furthermore, posterior capsular folds may have connection with the occurrence of the posterior capsular opacification[5]. Posterior capsular folds are of great significance for the refinement of cataract surgery. However, the mechanisms of posterior capsular folds formation are still unclear.

The main focus of our study was to investigate how the different IOL loops types affect posterior capsule folds

formation. In this study, three different types of IOLs were chosen: HOYA PY60AD, Bausch&Lomb AO and AMO Tecnis ZCB00, which share similar design of optical part, but differ in haptic design. We compared the incidence of posterior capsule folds among three types of IOLs. Then multivariate logistics regression analysis was conducted to determine risk factors of posterior capsule folds.

## SUBJECTS AND METHODS

**Ethical Approval** This retrospective study was performed at the Department of Ophthalmology, Zhongnan Hospital of Wuhan University, and was approved by the Institute Research Medical Ethics Committee of Zhongnan Hospital, Wuhan University. Informed consent was waived due to the retrospective nature of the study.

**Patients** From August 2016 to April 2017, we collected the data of patients who had undergone phacoemulsification (PHACO) combined with IOL implantation surgery. By reviewing the medical files, records were analyzed on preoperative axial length, types of IOLs and postoperative intraocular pressure (IOP). Inclusion criteria were the patients implanted one or two of the three types of IOLs: HOYA PY60AD (Hoya Corporation, Japan), Bausch&Lomb AO (Bausch & Lomb Incorporated, America) and AMO Tecnis ZCB00 (Abbott Medical Optics Incorporated, America). Exclusion criteria were dislocation of lens, incomplete posterior capsule (i.e. posterior capsule has coloboma or get impaired for any reason), age younger than 40y, a history of ocular disease, intraocular surgery, laser treatment, diabetes requiring medical control, glaucoma, uveitis, pseudoexfoliation and posterior segment pathology, dilated pupil diameter less than 5 mm.

**Materials** We chose three types of IOLs for research: HOYA PY60AD, Bausch&Lomb AO and AMO Tecnis ZCB00. The three types of IOLs have different haptic designs and other design factors are consistent, such as aspheric surface, negative spherical aberration (SA), square edge, and optic diameter of 6.0 mm. HOYA PY60AD IOL has two haptics, which are made of polymethacrylates (PMMA). Bausch&Lomb AO IOL has four haptics, which are made of acrylic. AMO Tecnis ZCB00 IOL has 2 haptics, which are made of acrylic (Table 1).

**Surgical Methods** All patients had standard cataract surgery performed by a single experienced surgeon (Cai XJ) using peribulbar anesthesia. A 3-mm limbus tunnel incision was made, and the anterior chamber was reformed with sodium hyaluronate 1%. A capsulorhexis was created, aiming for good centration and a 5.0 mm diameter. The nucleus was removed by PHACO-chop technique under Alcon ultrasonic emulsification system (Alcon Laboratories Incorporated, America) and lens cortex was removed by by irrigation/aspiration (I/A) with balanced salt solution (BSS). Lens epithelial cells (LECs) were cleared by polishing posterior capsule and no attempt was made to remove LECs by polishing the anterior capsule. The bag was reformed with viscoelastic agent and the section enlarged, then IOL was implanted in the bag. The viscoelastic agent was removed by I/A with BSS. Surgical complications such as posterior capsular rupture led to patient exclusion.

**Assessement of Posterior Capsule Folds** Postoperatively, all patients used pranoprofen drops and tobramycin and dexamethasone drops 4 times a day. Patients were examined 2d after surgery. We used tropicamide-phenylephrine ophthalmic solution for dilating pupils, then observed posterior capsule under the slit-lamp microscope when pupil diameter was between 5-6 mm. The criterion of posterior capsule folds is observable linear fold on the central 5mm zone of posterior capsule. The observations and records were done by a single researcher (Zhang LL).

**Data Analysis** The statistical analysis was performed using the SPSS (version 21.0). Clinical factors were analysed through Chi-square test and one-way ANOVA. Multivariate logistics regression analysis was conducted to determine risk factors of capsule folds. *P* values below 0.05 were considered statistically significant.

## RESULTS

**Basic Characteristics of Patients** We observed 242 eyes (187 patients) that matched inclusion and exclusion criteria. There were no complications during and after the cataract surgery. Among 242 eyes underwent PHACO and implanted with IOLs, 80 eyes of 59 patients implanted with HOYA PY60AD IOLs, 81 eyes of 59 patients implanted with Bausch&Lomb AO IOLs, 81 eyes of 69 patients implanted with AMO Tecnis ZCB00 IOLs. The basic characteristics of patients are summarized in Table 2. There was no statistical significance among the patients who implanted different IOLs ($P>0.05$).

**Comparison of Posterior Capsule Folds Incidences** The measurement of posterior capsule folds was obtained at 2d postoperatively. Observed formation of posterior capsule folds was considered positive. Among the patients implanted HOYA PY60AD IOLs, 45 eyes out of 80 eyes (56.3%) formed posterior capsule folds. The positive rate of the patients implanted Bausch&Lomb AO IOLs is 14.8% (12 out of 81). The positive rate of the patients implanted AMO Tecnis ZCB00 IOLs is 38.3% (31 out of 81). Chi-square test analysis showed the difference between positive rate of patients implanted AMO Tecnis ZCB00 IOLs and that of patients implanted HOYA PY60AD IOLs was statistically significant, also, the difference between positive rate of patients implanted AMO Tecnis ZCB00 IOLs and that of patients implanted Bausch&Lomb AO IOLs was statistically significant (Table 3).

**Multivariate Logistics Regression Analysis** Furthermore, multivariate logistics regression analysis was conducted

**Table 1 Brief introduction of the three intraocular lens**

| Parameters | HOYA PY60AD | Bausch&Lomb AO | AMO Tecnis ZCB00 |
|---|---|---|---|
| Optical characteristics | Aspheric surface/negative SA | Aspheric surface/negative SA | Aspheric surface/negative SA |
| Optic diameter | 6 mm | 6 mm | 6 mm |
| Edge design | 360° polish square edge | 360° polish square edge | 360° polish square edge |
| IOLs length | 12.5 mm | 10.5-11.0 mm | 13 mm |
| Angle between optic and haptics | 5° | 0° | 5° |
| IOLs material | Hydrophobic acrylic | Hydrophilic acrylic | Hydrophobic acrylic |
| Number of haptic | 2 | 4 | 2 |
| Material of haptic | Polymethyl methacrylate | Acrylic | Acrylic |

IOL: Intraocular lens.

**Table 2 The basic characteristics of patients implated with different IOLs**

| Parameters | HOYA PY60AD (*n*=80) | Bausch&Lomb AO (*n*=81) | AMOTecnis ZCB00 (*n*=81) | $\chi^2$ | *P* |
|---|---|---|---|---|---|
| Age (y) | | | | 1.392 | 0.59 |
| ≤70 | 32 | 38 | 31 | | |
| >70 | 48 | 43 | 50 | | |
| Sex | | | | 1.11 | 0.57 |
| M | 35 | 36 | 30 | | |
| F | 45 | 45 | 51 | | |
| IOP (mm Hg) | 13.26±0.39 | 13.48±0.36 | 13.47±0.34 | 0.58 | 0.94 |
| Axial length (mm) | 23.68±0.11 | 23.69±0.10 | 23.66±0.10 | 0.016 | 0.98 |

IOL: Intraocular lens; IOP: Intraocular pressure.

**Table 3 Comparison of posterior capsule folds incidences**

| IOLs | *n* | Posterior capsule folds | | $\chi^2$ | *P* |
|---|---|---|---|---|---|
| | | Positive (%) | Negative (%) | | |
| HOYA PY60AD | 80 | 45 (56.3) | 35 (43.8) | 5.220[a] | 0.027 |
| Bausch&Lomb AO | 81 | 12 (14.8) | 69 (85.2) | 11.429[a] | 0.001 |
| AMO Tecnis ZCB00 | 81 | 31 (38.3) | 50 (61.7) | - | - |

IOL: Intraocular lens. [a]Compared with the incidence of posterior capsule folds in patients with AMO Tecnis ZCB00.

to determine risk factors of capsule folds. We compared all the positive cases and negative cases from the factors including age, sex, axial length, IOP and IOLs types. The results demonstrated that IOLs types and axial length were independent risk factors. Compared with AMO Tecnis ZCB00 IOLs, using HOYA PY60AD IOLs increases the risk of posterior capsule folds [*P*=0.020, OR (95%CI)=2.145 (1.129, 4.073)], while using Bausch&Lomb AO IOLs reduces the risk [*P*=0.001, OR (95%CI)=0.274 (0.127, 0.591)]. Shorter ocular axis may increase the risk of posterior capsule folds [*P*=0.012, OR (95%CI)=0.669 (0.489, 0.915)], Table 4.

**Table 4 Multivariate logistics regression analysis**

| Factors | Logistics analysis | |
|---|---|---|
| | *P* | OR (95%CI) |
| Sex | 0.941 | - |
| Age | 0.160 | - |
| Axial length | 0.012 | 0.669 (0.489, 0.915) |
| IOP | 0.818 | - |
| HOYA PY60AD IOL | 0.020 | 2.145 (1.129, 4.073) |
| Bausch&Lomb AO IOL | 0.001 | 0.274 (0.127, 0.591) |

IOP: Intraocular pressure; IOL: Intraocular lens.

## DISCUSSION

Posterior capsule fold is a common phenomenon after PHACO combined with IOLs implantation[6]. Accumulated evidences have indicated posterior capsule folds have impact on postoperative visual acuity of cataract patients. It impedes the perfection process of cataract surgery and Nd: YAG laser release incision of posterior capsular folds causes additional financial burden for patients. However, the mechanism of posterior capsular folds formation remains largely unclear.

In this study we explored the connection between posterior capsular folds and IOLs haptic design. The positive rate of patients implanted with HOYA PY60AD IOLs (56.3%) is significantly higher than that of patients implanted with AMO Tecnis ZCB00 IOLs(38.3%). HOYA PY60AD IOL and AMO Tecnis ZCB00 IOL both have two lens haptics. This result may be explained by the different material of the two types of IOL haptics. HOYA PY60AD IOL haptics are made of PMMA and AMO Tecnis ZCB00 IOL haptics are made of acrylic acid.

Compressive resistance of PMMA is close to 7 times than that of acrylic acid[7-8]. More compressive resistive IOL haptics lead have higher pressure on the contact point between IOL and the lens capsule[5], thus leading to greater tension on posterior capsule between the two contact points. Insufficient pressure of contact between haptics and capsular bag leads to unstable fixation[9] while high pressure on the contact point stretching of the capsular bag leading to the formation of posterior capsule folds[10]. This result of our study is consistent with previously study, which showed using MA60BM IOLs (haptics made of PMMP) increases the incidence of posterior capsular folds compared with SA30AL IOLs (haptics made of acrylic acid)[11]. Our study had a larger sample and provided a stronger evidence for the connection between posterior capsular fold and haptic material. What's more, the IOLs explored in this study are frequently used currently and provide suggestion for surgeons in the selection of intraocular lenses.

Among the patients implanted Bausch&Lomb AO IOLs, 12 eyes out of 81 eyes (14.8%) formed posterior capsule folds, incidence of which is significantly lower than that of AMO Tecnis ZCB00 IOL. Both of the two types of IOLs have haptic made of acrylic acid. However, AMO Tecnis ZCB00 IOL has two haptics while Bausch&Lomb AO IOL has four haptics. Compared with two-haptics IOL, four-haptics IOL leads to the pressure on the capsule bag being dispersed. For this reason, it is more difficult to form posterior capsule folds. Similar result has been achieved by previous study[12], which found incidence of posterior capsule folds of patients with four-haptics IOLs is lower than that of patients with two-haptics IOLs. In this study, among patients with four-haptics IOLs, none of the patients formed posterior capsule folds one day postoperatively. In our research, patients with Bausch&Lomb AO IOLs have the lowest incidence, but posterior capsule folds still formed in 14.8% of the patients. The reason for the discrepancy may be derived from the differences of case screening criteria and posterior capsule folds assessment. In our study, we have a stricter inclusion criteria and exclusion criteria. In our study, the observer who evaluated the capsule folds cannot be completely blinded off the information of implanted IOLs. So this limitation should be also taken into consideration.

Furthermore, though multivariate logistics regression analysis, IOLs types and axial length were identified as independent risk factors. Using HOYA PY60AD IOL and shorter ocular axis increase the risk of posterior capsule folds. The ocular axis can indirectly reflect the size of the lens capsule: the shorter the ocular axis, the smaller the capsular bag[13]. For patients with smaller capsular bag, the IOL haptics are relatively larger, thus generate greater force on the bag, which may cause the posterior capsular folds. Therefore, even if implanted with the same types of IOL, patients with shorter ocular axis more likely to form posterior capsular folds.

Posterior capsular folds may have bad impact on cataract surgery effect and reduce patient satisfaction postoperatively. First, it interferes with the normal ocular refractive system. Light travelling through eye depends a complex optical system. Homogeneity of light refraction of the optical system is related with the distances between components and the overall focal length of an optical system[14]. The existence of posterior capsular folds increases unevenly the distance between the posterior capsule membrane and IOL, thus result in an abnormal light refraction in optical system of the eye[15]. The presence of scattered light in the field of vision leads to disability glare[16]. Visual quality questionnaire survey showed disability glare is the chief and most annoying postoperative complaint of patients[17]. Second, previous study indicated that posterior capsular opacification (PCO) is related with posterior capsular folds. Six months after implantation of Hydroview H60M IOLs, 46% patients formed posterior capsular folds, the direction of which is consistent with the emergence of the LECs proliferation [8]. A recent study shows that existence of multiple striae persisting in patients beyond 6mo after operation is a contributing factor leading to the PCO development[18]. In this study, the rate of posterior capsule folds is lower in Bausch&Lomb AO IOL, which is hydrophilic acrylic IOL, than HOYA PY60AD IOL and AMO Tecnis ZCB00 IOL, which are hydrophobic acrylic IOLs. Accumulated evidences have proved that the rate of PCO is higher in hydrophilic IOLs than in hydrophobic acrylic IOLs[19-20]. It is reasonable to speculate that the difference may result partly from less posterior capsule folds occurrence in hydrophobic acrylic IOLs. The process of PCO starts from proliferation and migration of LECs[21]. Currently, the square angle design make the capsular membrane tightly wrap around the rim of the intraocular lens, thus forming a discontinuous sharp bend on capsular membrane and blocking the migration of epithelial cells[20,22]. However, the existence of posterior capsular folds leaves a space between capsular membrane and IOL. This space provides channel for proliferation and migration of lens epithelial cell, which finally develop into PCO. Therefore, posterior capsular folds will have bad influence on cataract surgery outcome. Haptic design should be an important consideration in IOL design and the research about the mechanism of its formation are urgently needed.

Our study introduced a new direction for further research of cataract surgery and provided evidences for selection of IOLs. Compared with AMO Tecnis ZCB00 IOLs, using HOYA PY60AD IOLs is more likely to lead to posterior capsule folds formation, while using Bausch&Lomb AO IOLs is less likely to lead the formation. The posterior capsule folds were less engendered in eyes with shorter were ocular axis.

The stabilities of the three types of IOLs have no statistical difference[8,23]. In order to minimize the risk of posterior capsule folds occurrence, Bausch&Lomb AO IOL is a better choice than HOYA PY60AD IOL and AMO Tecnis ZCB00 IOL.

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**REFERENCES**

1 Hawlina G, Perovšek D, Drnovšek-Olup B, MoŽina J, Gregorčič P. Optical coherence tomography for an in-vivo study of posterior-capsule-opacification types and their influence on the total-pulse energy required for Nd:YAG capsulotomy: a case series. *BMC Ophthalmol* 2014;14:131.

2 Kanellopoulos AJ, Asimellis G. Standard manual capsulorhexis / Ultrasound phacoemulsification compared to femtosecond laser-assisted capsulorhexis and lens fragmentation in clear cornea small incision cataract surgery. *Eye Vis (Lond)* 2016;3:20.

3 Yang J, Wu B, Sun F, Qin HY, Yang XL, Ren ZK. Nd:YAG laser release incision of posterior capsular membrane ruffles. *International Eye Science* 2013;13(9):1893-1895.

4 Zhang XJ, Yuan L. Effect of posterior capsular folds on visual acuity. *Chinese Journal of Practical Ophthalmology* 2005;23(2):141-142.

5 Meacock WR, Spalton DJ. Effect of intraocular lens haptic compressibility on the posterior lens capsule after cataract surgery. *J Cataract Refract Surg* 2001;27(9):1366-1371.

6 Wolken MA, Oetting TA. Linear posterior capsule opacification with the AcrySof intraocular lens. *J Cataract Refract Surg* 2001;27(11):1889-1891.

7 Saldanha MJ, Benjamin L, Patel CK. Postoperative rotation of a 3-piece loop-haptic acrylic intraocular lens. *J Cataract Refract Surg* 2009;35(10):1751-1755.

8 Yu F, Chang P, Li J, Zhou Y, Zhao Y. Comparative study of the tilt, decentration and higher-order aberrations (HOA) of single-piece and 3-piece tecnis aspheric intraocular lenses. *Zhonghua Yan Ke Za Zhi* 2015;51(4):270-275.

9 Lim SJ, Kang SJ, Kim HB, Apple DJ. Ideal size of an intraocular lens for capsular bag fixation. *J Cataract Refract Surg* 1998;24(3):397-402.

10 Assia EI, Apple DJ. Side-view analysis of the lens. II. Positioning of intraocular lenses. *Arch Ophthalmol* 1992;110(1):94-97.

11 Blomquist PH, Kelly JL. Posterior capsule folds and removal of ophthalmic viscosurgical devices. *J Cataract Refract Surg* 2002;28(9): 1565-1567.

12 Ma XL, Zhang XH, Huang D. The effect of Akreos Adapt IOL for posterior capsular wrinkle. *Journal of Aerospace Medicine* 2012;3(23): 262-264.

13 Kim JH, Lee D, Cha YD, Oh SH, Mah KC, Lee MS. The analysis of predicted capsular bag diameter using modified model of capsule measuring ring in Asians. *Clin Exp Ophthalmol* 2008;36(3):238-244.

14 Capoğlu IR, Taflove A, Backman V. Generation of an incident focused light pulse in FDTD. *Opt Express* 2008;16(23):19208-19220.

15 Ranasinghesagara JC, Hayakawa CK, Davis MA, Dunn AK, Potma EO, Venugopalan V. Rapid computation of the amplitude and phase of tightly focused optical fields distorted by scattering particles. *J Opt Soc Am A Opt Image Sci Vis* 2014;31(7):1520-1530.

16 Zheng YW, Zhao JY, Ma LW, Chen SY, Yu ZY, Shi D, Zhang JS. Consensus and new improvements of disability glare. *International Eye Science* 2014;14(12):2185-2189.

17 Kinard K, Jarstad A, Olson RJ. Correlation of visual quality with satisfaction and function in a normal cohort of pseudophakic patients. *J Cataract Refract Surg* 2013;39(4):590-597.

18 Joshi RS. Postoperative posterior capsular striae and the posterior capsular opacification in patients implanted with two types of intraocular lens material. *Indian J Ophthalmol* 2017;65(6):466-471.

19 Chang A, Kugelberg M. Posterior capsule opacification 9 years after phacoemulsification with a hydrophobic and a hydrophilic intraocular lens. *Eur J Ophthalmol* 2017;27(2):164-168.

20 Bai L, Zhang J, Chen L, Ma T, Liang HC. Comparison of posterior capsule opacification at 360-degree square edge hydrophilic and sharp edge hydrophobic acrylic intraocular lens in diabetic patients. *Int J Ophthalmol* 2015;8(4):725-729.

21 Vasavada AR, Praveen MR, Shah GD, Johar K, Sankaranarayanan R. A prospective evaluation of posterior capsule opacification in eyes with posterior capsule plaque-A case-control study. *Asia Pac J Ophthalmol (Phila)* 2017;6(1):13-20.

22 Haripriya A, Chang DF, Vijayakumar B, Niraj A, Shekhar M, Tanpreet S, Aravind S. Long-term posterior capsule opacification reduction with square-edge polymethylmethacrylate intraocular lens: randomized controlled study. *Ophthalmology* 2017;124(3):295-302.

23 Xing XJ, Tang X, Song H. Comparison of optical performance and stability of five different kinds of aspheric IOLs. *Zhonghua Yan Ke Za Zhi* 2012;48(4):297-301.