Original Article

Analysis of Corneal Spherical Aberration in Patients before and after Phacoemulsification

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Abstract

Purpose: To investigate the distribution and changes in corneal four-order spherical aberration Z_4^0 in patients with age-related cataract before and after phacoemulsification, and to direct the application of aspherical intraocular lens (IOL) in PHACO combined with IOL implantation.

Methods: A total of 155 eyes in 93 patients with age-related cataract were included. All patients received a comprehensive ophthalmologic examination. Corneal Z_4^0 at a pupil diameter of 6 mm was measured by using a Scheimpflug photography system (Pentacam) preoperatively and 3 months postoperatively.

Results: The mean corneal Z_4^0 before and after the PHACO at a diameter of 6 mm was (0.294±0.138) μm and (0.271±0.130) μm, respectively, with statistical significance (P<0.05, t=4.384). There was no significant difference between male (n=45, 76 eyes) and female patients (n=48, 79 eyes) regarding corneal Z_4^0 (t=–0.418, P=0.676). The corneal Z40 for patients (35 eyes) aged from 50 to 59 years was (0.238±0.104) μm preoperatively; (0.308±0.104) μm for 60 to 69 years; (0.332±0.151) μm for 70 to 79 years; and (0.307±0.164) μm for 80 to 89 years. A significant difference in Z_4^0 was observed among different age groups. A linear positive correlation was noted between corneal Z_4^0 and ages (r=0.203, P<0.003).

Conclusion: The corneal Z_4^0 varied significantly among cataract patients. Patients' corneal Z_4^0, which should be considered when choosing aspherical IOL, increases slightly with age. Thus, customized aspheric IOLs are needed. (***Eye Science 2012; 27: 165–168***)

Keyword: corneal wavefront aberration; intraocular lens; cataract extraction

Phacoemulsification combined with IOL implantation has been frequently applied in the treatment of cataract. More attention has been paid to reducing postoperative spherical aberration in eyes with implanted IOL and enhancing the patients' visual quality. The design of aspherical IOL is based upon corneal spherical aberration and has been widely applied in IOL implantation, aiming to reduce corneal aberration, decrease postoperative overall corneal spherical aberration in IOL-implanted eyes, and increase visual acuity. Before selecting suitable aspherical IOL, the distribution of corneal spherical aberration should be understood, the patients' corneal spherical aberration should be precisely measured, and the influence of phacoemulsification on corneal spherical aberration should be clarified. This study investigates the distribution of corneal spherical aberration in patients with age-related cataract and the impact of phacoemulsification with a 3.2 mm transparent corneal incision upon corneal spherical aberration.

Materials and methods

Study subjects

A total of 93 patients (155 eyes) with age-related cataract, 45 male, 48 female, aged from 51 to 84 years and (68±9) years on average, were admitted to the Department of Ophthalmology in Chinese PLA General Hospital between June 2010 and September 2010. The inclusion criteria were as follows: patients with age-related cataract aged from 50 to 89 years; preoperative axial length: 22 mm ~26 mm; normal cognitive ability; full exposure of palpebral fissure; normal tear film; and the ability to participate in the follow up. The exclusion criteria were as follows: a history of ocular trauma, fundus diseases, glaucoma and corneal defects; undergoing corneal refractive surgery; keratoconus or dry eyes; systemic connective tissue diseases and severe au-

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toimmune diseases, such as systemic lupus erythematosus and rheumatoid arthritis, etc.; postoperative complications, including elevated intraocular pressure and endophthalmitis, etc.

Clinical observations

1.Slit lamp microscope examination: The degree of corneal edema, incision recovery, and anterior chamber reaction were observed preoperatively and at 1 day, 1 week and 3 months postoperatively. 2.The corneal spherical aberration (simulated pupil diameter=6 mm) was measured using a high-resolution (HR) Pentacam Scheimpflug camera by one surgeon before and 3 months after surgery. Obtained data with good repeatability and intact tear film (measured three times) were averaged and included in the study.

Surgical approach

All operations were performed under ocular surface anesthesia with transparent corneal incisions: the main incision was made at 10 o'clock position of the transparent corneal limbus using a 3.2 mm–disposable keratome. Assisted incision was located at 2 o'clock above the corneal limbus using a 15° cornea paracentesis knife. All surgeries were performed by one proficient surgeon.

Statistical analysis

The data were analyzed using SPSS17.0 statistical software. The corneal spherical aberration was compared before and after the operation using a paired sample *t*-test. Z_4^0 at a pupil diameter of 6 mm was statistically compared among 50~59 (n=35), 60~69 (n=44), 70~79 (n=48) and 80~89 years (n=28) groups using SNK-q test.The correlation between age and corneal spherical aberration was analyzed by the product difference method. $P<0.05$ was considered statistically significant.

Results

Distribution and comparison of Z_4^0 before and after surgery (pupil diameter=6 mm)

The Z_4^0 in the diameter measurement group presented with normal distribution (P=0.773) before the operation, as indicated in Figure 1. The Z_4^0 in the 6 mm-pupil diameter group showed normal distribution (P=0.254) post operation, as illustrated in Figure 2. The mean±SD (95% CI) of Z_4^0 (pupil diameter=6 mm) before and after surgery is shown in Table 1. A significant difference was observed between the two groups (t=4.384, $P<0.05$).

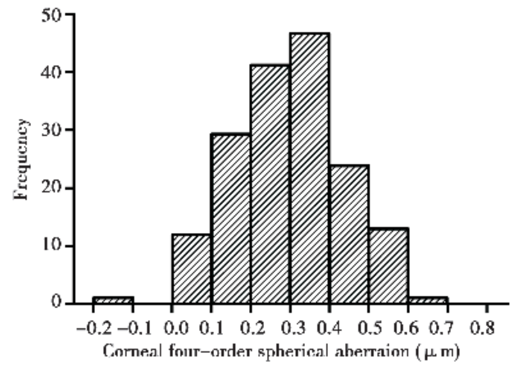

Figure 1 The frequency distribution of Z_4^0 before the PHACO for 6 mm diameter

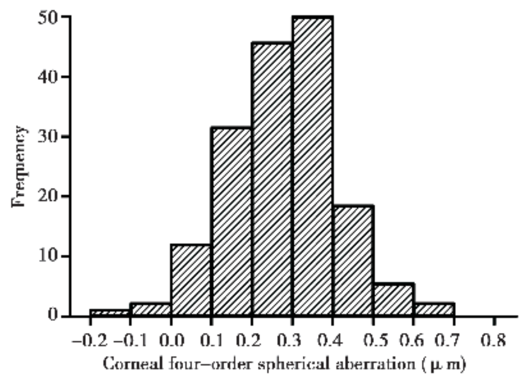

Figure 2 The frequency distribution of Z_4^0 after the PHACO for 6 mm diameter

The ratio of Z_4^0 before and after surgery in cataract patients of both genders

No statistical significance was noted in Z_4^0 (pupil diameter=6 mm) between both genders preoperatively and postoperatively, as shown in Table 2.

Comparison of Z_4^0 among different age groups before and after surgery

The obtained comparison results of Z_4^0 at a 6 mm

Table 1 The corneal Z_4^0 in groups before and after operation

Groups	Z_4^0 for 6 mm (μm, $\bar{x}\pm s$)	95% Confidence interval of the difference (μm)
Pre-operation (n=155)	0.294±0.138*	0.272 to 0.316
3 month after operation (n=155)	0.271±0.130*	0.251 to 0.292

* Indicates: $P<0.05$ t=4.384

Table 2 Comparison on the corneal Z_4^0 between white male and female

Groups	Pre−operation(μm, $\bar{x}\pm s$)	3 month after operation(μm, $\bar{x}\pm s$)
Z_4^0 for 6mm of male(n=155)	0.289±0.132[a]	0.275±0.132[b]
Z_4^0 for 6mm of female(n=155)	0.298±0.144[a]	0.268±0.130[b]

a indicates: P=0.676 b indicates: P=0.733

Table 3 Comparison on the difference of corneal Z_4^0 among four groups

Groups	Pre−operation(μm, $\bar{x}\pm s$)	3 month after operation(μm, $\bar{x}\pm s$)
Z40 for 50−59Y(n=35)	0.238±0.104	0.226±0.089
Z40for 60−69Y(n=44)	0.308±0.113	0.276±0.103
Z40 for 70−79Y(n=48)	0.332±0.151[a]	0.312±0.144[b]
Z40for 80−89Y(n=28)	0.300±0.164	0.267±0.168

Note: [a]P<0.05, vs Z_4^0 for 50−59Y(Pre−operation) [b]P<0.05, vs Z_4^0 for 50−59Y(3 month after operation)

of pupil diameter among various groups were shown in Table 3. A slightly positive correlation was noted between age and preoperative Z_4^0(r=0.203, P=0.011), as shown in Figure 3.

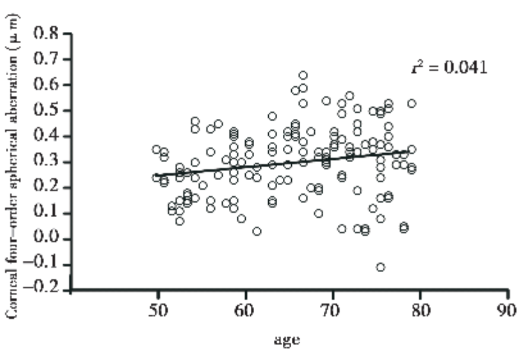

Figure 3 Relation between age and corneal Z_4^0(6mm)

Discussion

Fluctuation and distribution of corneal Z_4^0

Although the human cornea is aspherical, corneal spherical aberration can still be observed. Nvxia Tong et al[1].assessed the corneal spherical aberration of 144 cataract patients (188 eyes), indicating that positive spherical aberration was noted in anterior corneal surface of most patients: (0.231±0.092) μm on average (pupil diameter=6 mm) with a fluctuating range of -0.096 μm~+0.469 μm. Wang et al[2]. observed 228 eyes in 134 cases, aged from 20 to 79 years and found that spherical aberration of the anterior corneal surface significantly varied among individuals, (0.280±0.086) μm on average and all results were positive. He et al[3].measured spherical aberration of the anterior corneal surface in 45 young subjects aged between 9 and 29 years and noted that the mean coefficient of spherical aberration was (0.3 ±0.08) μm. Beiko et al[4].measured the corneal spherical aberration in 696 healthy participants with an average value of (0.27±0.089) μm and fluctuating range between+0.041 and +0.632 μm. These previous studies calculated the anterior corneal spherical aberration based upon corneal topography. Dubbel man et al[5].assessed corneal spherical aberration using a Scheimpflug camera and suggested that anterior corneal spherical aberration differed from anterior-posterior overlay corneal spherical aberration by approximately 5%. Therefore, this study employed a Scheimpflug camera to measure the spherical aberration of anterior corneal surface and posterior surface overlapping posterior spherical aberration, that is, whole corneal spherical aberration. The results of this investigation revealed that corneal spherical aberration significantly varied among individuals, which is consistent with previous studies. The mean corneal spherical aberration at 6 mm pupil size was (0.294±0.138) μm before operation and decreased to (0.271±0.130) μm after the operation, fluctuating from −0.111 μm to +0.639 μm, which indicated significant individual differences regarding corneal spherical aberration. According to Beiko et al[4]., corneal spherical aberration cannot be predicted by Q value due to poor correlation. They proposed the strategy of selecting aspherical IOL based on corneal spherical aberration.

The influence of age on corneal spherical aberration

A previous study[6] reported that corneal spherical aberration is primarily caused by IOL changes and constantly increases with age. However, other studies proved that corneal spherical aberration gradually increased with age in adults aged between 40 and 50 years[7,8]. In this study, we found that corneal spherical aberration in 70-year-old patients was significantly higher compared with patients aged 50 years. In addition, we noted a poor positive correlation between age and corneal spherical aberration in patients between 50 and 80 years. The statistical results also revealed that corneal spherical aberration significantly differed among populations of various ages. Thus, it is not feasible to evaluate corneal spherical aberration and choose individual IOL according to age.

The influence of cataract on corneal spherical aberration

Haiwu Li et al[9].compared the Q values of 30 patients (39 eyes) with age–related cataract before and after surgery and found that although no statistical significance was noted in Q values before and after phacoemulsification with 3 mm transparent corneal incision (t=1.14, P=0.26), postoperative corneal Q value showed a descending tendency compared with that before operation. A previous study observed a positive correlation between Q value and spherical aberration of anterior corneal surface (r=–0.725, P=0.000)[1], suggesting that corneal spherical aberration possibly presents with a decreasing trend postoperatively. In this study, preoperative corneal spherical aberration was (0.294±0.138)μm and significantly declined to (0.271±0.130)μm after phacoemulsification with 3.2 mm transparent corneal incision (P<0.01), which might induce the decrease of postoperative corneal spherical aberration. Similarly, Marcos et al[10].implanted two types of aspherical IOLs via 3.2 mm transparent corneal incision intraoperatively and found that corneal spherical aberration at 5 mm pupil size decreased from (0.13±0.05) μm preoperatively to (0.11±0.06) μm postoperatively in the Tecnis IOL group (P=0.06), whereas no significant difference was observed in corneal spherical aberration before and after surgery (P=0.52) in the AcrySof IQ IOL group.They suggested that postoperative changes in corneal spherical aberration might be caused by IOL implantation or IOL injector. However, Iseli et al[11].found that although phacoemulsification caused an increase in coma and other high order aberration, it did not affect the corneal spherical aberration. Some scholars compared the corneal high order aberration by performing surgeries with transparent corneal incision of various sizes. Yao et al[12].noted no statistical significance in the spherical aberration of corneal anterior surface after phacoemulsification with 1.5 mm and 3.2 mm transparent corneal incisions(P=0.68). Denoyer et al[13]. also observed no significant difference in spherical aberration of corneal anterior surface post surgeries with 1.7 mm and 2.8 mm transparent corneal incisions (P=0.55). In this study, the corneal spherical aberration changes before and after surgery might be explained by the significant whole-corneal spherical aberration induced by spherical aberration of posterior corneal surface intraoperatively. However, a limitation of this study is that whether the spherical aberration of corneal anterior surface changes has not been investigated, which will be discussed in further studies.

In summary, corneal spherical aberration varies considerably among cataract individuals. Furthermore, corneal aberration might be affected by surgery or incision size. Thus, the selection of aberration-free IOL should be personalized.

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