·Clinical Research·

Corneal biomechanical properties changes after coaxial 2.2-mm microincision and standard 3.0-mm phacoemulsification

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Abstract

• AIM: To compare the changes in corneal biomechanics measured by ocular response analyzer (ORA) after 2.2-mm microincision cataract surgery and 3.0-mm standard coaxial phacoemulsification.

• METHODS: The prospective nonrandomized study comprised eyes with cataract that had 2.2-mm coaxial microincision or 3.0-mm standard incision phacoemulsification. The corneal hysteresis (CH), corneal resistance factor (CRF), corneal-compensated intraocular pressure (IOPcc) and Goldmann-correlated intraocular pressure (IOPg) were measured by ORA preoperatively and at 1d, 1-, 2-, 3- and 4-week postoperatively. Results were analyzed and compared between groups.

• RESULTS: In both groups, CH decreased in the immediate postoperative period (P<0.05), returned to the preoperative level at one week (P=0.249) in the 2.2-mm group, and at two weeks in the 3.0-mm group (P=0.264); there was no significant change in CRF values. In 2.2-mm group, mean IOPcc and IOPg increased at 1d postoperatively (both P<0.05), and returned to preoperative level at one week (P=0.491 and P=0.923, respectively). In 3.0-mm group, mean IOPcc and IOPg increased at 1d and 1wk postoperatively (P=0.005 and P=0.029, respectively), and returned to preoperative level at 2wk (P=0.347 and P=0.887, respectively).

• CONCLUSION: Significant differences between preoperative and postoperative corneal biomechanical values were found for CH, IOPcc and IOPg. But the recovery time courses were different between the two groups. The 2.2-mm coaxial microincision cataract surgery group seemed recovery faster compared to the 3.0-mm standard coaxial phacoemulsification group.

• **KEYWORDS:** coaxial microincision cataract surgery; 2.2-mm microincision; corneal biomechanical parameters; time course

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INTRODUCTION

Cataract surgery changes the biomechanical properties of the cornea [1]. The ocular response analyzer (ORA, Reichert Ophthalmic Instruments, Buffalo, NY, USA) measures the biomechanical properties of the cornea *in vivo*. It provides several measurements, including corneal hysteresis (CH), corneal resistance factor (CRF), corneal-compensated intraocular pressure (IOPcc), and Goldmann-correlated intraocular pressure (IOPg)[2-3]. Although several studies have been done evaluating the relationship between cataract surgery and corneal biomechanical properties, the knowledge was still limited. According to these studies, changes in corneal biomechanical properties after cataract surgery vary. The length and architectural of intraoperative corneal incision may be significant factors affecting corneal biomechanics[4]. The purpose of our study was to compare the effects of 2.2-mm coaxial microincision cataract surgery and 3.0-mm standard coaxial phacoemulsification on corneal biomechanics. In addition, we provided the time course of corneal biomechanical changes after cataract surgery in Chinese.

SUBJECTS AND METHODS

Subjects This prospective, nonrandomized consecutive study involved patients with age-related cataract who were planning to have 2.2-mm coaxial microincision cataract surgery or 3.0-mm standard coaxial phacoemulsification. A total of 70 eyes from 70 patients were divided into two equal groups: 35 patients in the 2.2-mm group and 35 patients in the 3.0-mm group. All surgeries were performed by one experienced surgeon (Zhang SH) from June through

November 2012 at the Department of Cataract, Shanxi Eye Hospital. There were no ocular pathology of note and no history of previous ocular injury. None of these patients had undergone ocular surgery or were contact lens wearers. None of the patients had glaucoma or were using any topical medication. Two patients in the 2.2-mm group lost follow-up at 1mo postoperatively, and results in 33 patients were analyzed in the 2.2-mm group.

The study followed the tenets of the Declaration of Helsinki. The Ethics Committee of the Shanxi Eye Hospital approved the study protocol. After detailed explanation, informed consent was obtained from each patient prior to examination.

Methods

Surgical technique Topical anesthesia was employed with 0.05% Alcaine (Alcon). With the surgeon sitting superiorly, incisions were made at the 10 o'clock position with paracentesis at the 2 o'clock position. Two-step incisions were made using a stab blade, 0.5 mm from limbus, with a 2.2-mm or 3.0-mm clear corneal knife. A continuous curvilinear capsulorhexis measuring approximately 5.0 mm in diameter was created after the anterior chamber was inflated with a viscoelastic (DuoVisc, Alcon Laboratories Inc.). Nuclei were chopped after hydrodissection. The torsional mode (OZil handpiece, Alcon Laboratories Inc.) of the Infiniti Vision System was applied for the phacoemulsification of nuclear fragments. Bent MicroTips (0.9 mm) (Alcon Laboratories Inc.) was used for 3.0-mm incisions, and Kelman Mini-Flared tips (0.9 mm) (Alcon Laboratories Inc.) were used for 2.2-mm incisions. Tips had a 30-degree bevel. Standard sleeves were used for 3.0-mm incisions, and Ultra sleeves were used for 2.2-mm incisions (all sleeves from Alcon). An AcrySof IQ SN60WF intraocular lens (IOL) was implanted using the Monarch II IOL delivery system with the Monarch C cartridge. The viscoelastic was completely removed from the anterior chamber; incisions were sealed at the end of surgery. No intraoperative complications occurred. All patients were treated with topical TobraDex (Alcon) eye drops six times a day for 2wk.

Measurements of corneal biomechanical parameters and central corneal thickness Preoperatively, a full eye examination was performed, including visual acuity measurement, biomicroscopy of the anterior and posterior segment and tonometry. The CH, CRF, IOPcc, and IOPg were measured by the ORA (Reichert Ophthalmic Instruments, Buffalo, NY, USA) preoperatively and at 1d, 1-, 2-, 3-, and 4-week postoperatively[4]. CCT was measured with Orbscan II (Bausch & Lomb; GmbH, Feldkirchen, Germany) pachymetry followed by ORA examination. CCT, CH, CRF, IOPcc and IOPg measurements were repeated 3 times, and the mean values were recorded. All measurements were carried out during regular office hours between 8 a.m. and 5 p.m.

Statistical Analysis Statistical analysis was performed using the SPSS 16.0 for Windows software (SPSS, Inc., Chicago, IL, USA). Data were expressed as the mean±SD and range, normality of all data samples was first confirmed by the Kolmogorov-Smirnov test. Differences between preoperative and postoperative values for CH, CRF, IOPcc, and IOPg were analyzed using the paired *t*-test. The Student's *t*-test for unpaired data was used to compare the biomechanical parameters between the 2.2-mm group and 3.0-mm group. The Pearson correlation coefficient was performed to assess the relationship between CH and CCT. A two-tailed *P* value of <0.05 was considered significant.

RESULTS

Sixty-eight eyes of 68 patients were enrolled in this study. Thirty-three patients had 2.2-mm coaxial microincision cataract surgery and 35 had 3.0-mm standard coaxial phacoemulsification. All patients were Chinese. Patient demographics are summarized in Table 1. There were no differences between the two groups in general information.

The time courses of CH are shown in Table 2. In 2.2-mm group, mean CH decreased at 1d postoperatively (P=0.002), and returned to preoperative level at 1wk postoperatively (P=0.249). In 3.0-mm group, mean CH decreased at 1d and 1wk postoperatively (both P<0.05), and returned to preoperative level at 2wk (P=0.264).

The time courses of CRF are shown in Table 3. Compared to preoperative CRF values, there were no significant changes following the surgery in both groups.

The time courses of IOPcc are shown in Table 4. In 2.2-mm group, mean IOPcc increased at 1d postoperatively (P<0.001), and returned to preoperative level at 1wk postoperatively (P=0.491). In 3.0-mm group, mean IOPcc increased at 1d and 1wk postoperatively (both P<0.05), and returned to preoperative level at 2wk (P=0.347).

The time courses of IOPg are shown in Table 5. In 2.2-mm group, mean IOPg increased at 1d postoperatively (P=0.001), and returned to preoperative level at 1wk postoperatively (P=0.923). In 3.0-mm group, mean IOPg increased at 1d and 1wk postoperatively (both P<0.05), and returned to preoperative level at 2wk (P=0.887).

In 2.2-mm group, mean CCT increased at 1d and 1wk postoperatively (both P<0.05), and returned to preoperative level at 2wk postoperatively (P=0.100) (Table 6). In 3.0-mm group, mean CCT increased at 1d (P=0.001), and returned to preoperative level at 1wk (P=0.144).

Pearson correlation analysis showed statistically significant correlation between preoperative CH and preoperative CCT in both groups (2.2-mm group, r=0.359, P=0.040; 3.0-mm group, r=0.349, P=0.046, respectively). Postoperative, there were no significant correlations between CH and CCT at any visits.

Table 1 Summary of characteristics in each group

Parameters	Groups	
	2.2-mm (*n*=33)	3.0-mm (*n*=35)
Gender (*n*)		
M	21	16
F	12	19
Age (a)		
Mean	69.7±11.3	70.1±10.2
Range	37-86	46-86
LOCS III cataract grade, *n* (%)		
II	8 (24.2)	10 (28.6)
III	25 (75.8)	25 (71.4)
Mean incision size (mm)	2.23±0.14	3.14±0.23
Side-port incision size (mm)	1.02±0.11	1.07±0.15
Phaco time ($\bar{x} \pm s$, s)	37.56±31.29	34.66±40.29
Cumulative dissipated energy (%)	11.75±8.69	12.94±9.35

Table 2 Time course of CH mm Hg

Time	2.2-mm		3.0-mm	
	$\bar{x} \pm s$	*P*	$\bar{x} \pm s$	*P*
Preoperative	9.74±1.47		9.84±2.15	
Postoperative				
1d	8.73±2.10	0.002	8.92±1.97	0.021
1wk	9.26±1.63	0.249	8.94±0.91	0.009
2wk	9.32±1.49	0.226	9.52±1.79	0.264
3wk	9.83±0.95	0.784	9.51±1.07	0.940
4wk	9.86±1.75	0.611	9.81±2.10	0.509

Table 3 Time course of CRF mm Hg

Time	2.2-mm		3.0-mm	
	$\bar{x} \pm s$	*P*	$\bar{x} \pm s$	*P*
Preoperative	9.34±1.61		9.05±2.25	
Postoperative				
1d	9.42±2.45	0.904	9.24±2.27	0.741
1wk	9.19±1.74	0.388	8.65±1.53	0.263
2wk	9.23±1.40	0.219	8.69±2.24	0.313
3wk	9.54±1.71	0.568	8.61±1.72	0.483
4wk	9.22±1.83	0.434	8.72±2.17	0.275

Table 4 Time course of IOPcc mm Hg

Time	2.2-mm		3.0-mm	
	$\bar{x} \pm s$	*P*	$\bar{x} \pm s$	*P*
Preoperative	15.29±3.14		14.00±3.28	
Postoperative				
1d	18.59±5.97	<0.001	17.81±4.97	<0.001
1wk	16.28±5.97	0.491	15.93±2.85	0.005
2wk	16.32±3.46	0.687	14.28±3.21	0.347
3wk	15.25±3.35	0.441	12.69±2.33	0.905
4wk	15.13±3.16	0.433	13.89±3.31	0.444

Table 5 Time course of IOPg mm Hg

Time	2.2-mm		3.0-mm	
	$\bar{x} \pm s$	*P*	$\bar{x} \pm s$	*P*
Preoperative	13.94±3.39		12.52±3.16	
Postoperative				
1d	17.03±5.84	0.001	15.76±5.19	<0.001
1wk	14.68±2.61	0.923	13.59±3.45	0.029
2wk	14.56±3.12	0.772	12.26±4.00	0.887
3wk	14.13±4.17	0.281	11.03±1.60	0.239
4wk	13.08±3.31	0.050	11.51±3.84	0.865

Table 6 The values of CCT μm

Time	2.2-mm		3.0-mm	
	$\bar{x} \pm s$	*P*	$\bar{x} \pm s$	*P*
Preoperative	521.55±30.04		525.70±34.41	
Postoperative				
1d	577.73±83.25	<0.001	569.30±84.99	0.001
1wk	542.33±39.40	0.043	531.18±44.98	0.144
2wk	536.88±39.28	0.100	547.69±108.10	0.455
3wk	540.83±48.52	0.308	519.33±38.74	0.182
4wk	544.17±32.31	0.163	498.75±33.26	0.152

DISCUSSION

The biophysical factors that contribute to rigidity and elasticity of the corneal shape, have been studied in cases with cataract surgery, limbal relaxing incision after simultaneous phacoemulsification, laser *in situ* keratomileusis, keratoconus, glaucoma and Fuchs' corneal dystrophy [5-10]. According to the results of Alió *et al* 's study [11], biaxial microincision cataract surgery (1.2-1.4 mm incision) provide more stable corneal biomechanical properties than standard coaxial phacoemulsification (3.0-mm incision) 1mo postoperatively. In this study, we compared the time course of corneal biomechanical parameters after 2.2-mm coaxial microincision cataract surgery and 3.0-mm standard coaxial phacoemulsification. All measurements were obtained during office hours, because it has been shown that CH and CCT are almost constant throughout the day[12].

The CH factor is a dynamic measure of the viscous damping in the corneal tissue and represents the energy absorption capability of the cornea. In this study, CH significantly decreased in both groups on the first postoperative day. CH returned to the preoperative level by the end of the first week postoperatively in the 2.2-mm coaxial microincision group, but it did not recover until the end of 2wk postoperatively in 3.0-mm standard coaxial phacoemulsification group. According to a linear hypothesis, Kandarakis *et al* [13] estimated that CH would reach the preoperative value in approximately 14d following 2.75-mm incision coaxial phacoemulsification. de Freitas Valbon *et al* [14] reported that CH decreased significantly at 1d in 2.75-mm clear corneal incision phacoemulsification. We provide an actual rate of CH recovery with 2.2-mm and 3.0-mm incisions. Alió *et al* [11] reported the CH values significantly decreased in the immediate postoperative period, then returned to normal after

1mo in the biaxial microincision cataract surgery (1.2-1.4 mm). In their study, biomechanical waveform measurements were taken 1h and 1mo postoperatively. It was reported that surgically induced corneal astigmatism (SIA) was associated with preoperative CH[15].

In our study, in Chinese patients with mean age of around 70 years old, the average values of CH were close to 9.6 mm Hg, which are similar to results reported by Kamiya *et al* [16] in Japanese population. Large range of average values of CH in normal population has been reported in the literature (9.6-mm Hg to 12.2-mm Hg)[2,17]. Kamiya *et al* [18] reported that CH values were significantly decreased by aging without significant changes in CCT. Older age of patients with cataract enrolled in this study may contribute to these slightly lower values of CH.

CCT was measured with the integrated handheld ultrasonic pachymeter (20 MHz) from the ORA in several studies. Because we didn't have the set of handheld ultrasonic pachymeter, we recorded the CCT from Orbscan pachymetry map. On the first postoperative day, we found a statistically significant increase in CCT, which was similar to Hager's study [19]. Kamiya *et al* [16] found weak, but significant, correlations between CH and CCT before surgery, 1wk, 1mo, and 3mo after surgery, but no significant correlation between CH and CCT at 1d after 2.8-mm clear corneal incision cataract surgery. Kandarakis *et al* [13] showed that there was a positive correlation between CCT and CH preoperatively, which ceased to exist in the first postoperative day, this correlation was re-established 1wk later. We didn't find any relationship between CH and CCT postoperatively up to 4wk.

The CRF parameter is an indicator of the overall resistance of the cornea, reflects the rigidity of the corneal surface. In our study, CRF did not change after surgery, which is in agreement with Alió 's study[11].

Our study showed the values of IOPg and IOPcc increased at the first day after surgery, and returned to preoperative levels at 1wk in 2.2-mm group and at 2wk in 3.0-mm group. Alió *et al* [11] found statistically significant increase in IOPg and IOPcc immediately after surgery, and decreased significantly to preoperative levels after one month. Study from Kucumen *et al* [1] evaluated the IOPcc and IOPg preoperatively and at 1wk, and 1 and 3mo postoperatively. Compared to preoperative values, mean IOPcc was not significantly different at 1wk or 1mo; however, IOPcc was significantly lower at 3mo postoperatively (P=0.018). The change in the mean IOPg was not statistically significant between preoperatively and any postoperative time point (P>0.05).

Our study has limitations. We used the Orbscan II to obtain the CCT, because of the lack of CCT set with the ORA. The CCT values might be slight different from other studies of corneal biomechanical properties. Due to short term follow-up up to 4wk postoperatively, we did not find re-established correlation between CH and CCT after surgery. Study with long term follow-up is needed.

In summary, significant differences between preoperative and postoperative values were found for CH, IOPcc and IOPg. But the recovery time courses were different between the two groups. The 2.2-mm coaxial micro-incision cataract surgery group seemed recover faster compared to the 3.0-mm standard coaxial phacoemulsification group.

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