Current Eye Research, 37(1), 18–24, 2012

ISSN: 0271-3683 print/1460-2202 online
DOI: 10.3109/02713683.2011.622851

informa healthcare

ORIGINAL ARTICLE

Comparison of Corneal Aberrations After Biaxial Microincision and Microcoaxial Cataract Surgeries: A Prospective Study

İzzet Can[1], Hasan Ali Bayhan[2], Hale Çelik[2], and Başak Bostancı Ceran[2]

[1]*Director of Eye Department, Bozok University Faculty of Medicine, Yozgat, Turkey, and*
[2]*Atatürk Training and Research Hospital, 2nd Ophthalmology Department, Ankara, Turkey*

ABSTRACT

Purpose: To compare the effects of biaxial microincision cataract surgery (B-MICS) and microcoaxial cataract surgery (C-MICS) techniques on corneal optical quality.

Materials and methods: In this prospective study, 40 eyes underwent B-MICS and 40 eyes C-MICS. Corneal aberrations were derived from conversion of the corneal elevation profile into corneal wavefront data with 6.0 mm aperture diameter using Zernike polynomials by corneal topography preoperatively and 1 month postoperatively. Both magnitude and axes of surgically induced corneal aberrations were calculated.

Results: Mean final incision widths were 1.80 ± 0.09 mm and 1.89 ± 0.11 mm ($p = 0.062$) in B-MICS and C-MICS groups, respectively. There were no significant changes in total and higher order root mean square in both groups postoperatively. In B-MICS group, all aberration terms were similar, before and after surgery. However, vertical coma ($p = 0.002$), vertical trefoil ($p < 0.001$) and primary trefoil ($p = 0.042$) significantly increased postoperatively in the C-MICS group. Except surgically induced trefoil ($p = 0.047$), there was no significant difference in all surgically induced corneal aberrations between groups. The axes of the induced trefoil were found to be mostly related and close to the incision site in both groups which was more prominent in the C-MICS group.

Conclusions: Microincision cataract surgery techniques performed through sub-1.9 mm clear corneal incisions do not generally degrade optical quality of the cornea while only small amount of higher order aberrations seem to be induced with C-MICS technique.

Keywords: Microincision cataract surgery, Corneal wavefront aberrations, Optical quality of the cornea

INTRODUCTION

With the advance in technology, cataract surgery has evolved from a sight-saving operation to a refractive procedure. As a result, improvement of visual acuity alone is no longer adequate for surgical success; visual quality and optical outcomes are of great importance, as well. After this refractive procedure, aberrations generated by the cornea, intraocular lens and those induced by the surgery determine functional vision and affect patient satisfaction. Pseudophakic patients' ocular aberrations are significantly related to corneal aberrations, which forms a great part of the ocular aberrations.[1] Previous studies reported an increase in astigmatism[2,3] and higher order aberrations (HOA)[4,5] after conventional cataract surgery. HOAs are responsible from the complaints like glare, halo and ghost image[6,7] and cannot be corrected with spectacles in contrast to lower order aberrations (defocus and astigmatism).[8]

After cataract surgery, degradation of corneal optical properties influences visual quality of the patients, which has led cataract surgeons to perform surgery through smaller incisions. Major advantages of the smaller incision sizes are less surgically induced (SI) astigmatism, protection of corneal optical quality, rapid visual restoration with less iatrogenic corneal damage and minimum postoperative inflammation.[3,9–12]

Microincision cataract surgery (MICS) can be performed by two different techniques: bimanual and coaxial. Biaxial MICS (B-MICS) enables phacoemulsification through incisions as small as 1.2–1.4 mm,

Received 15 June 2011; revised 15 August 2011; accepted 08 September 2011

Correspondence: İzzet Can, Director of Eye Department, Bozok University Faculty of Medicine, Yozgat 66200, Turkey.
E-mail: izzetcan@yahoo.com

with separate instruments for phacoemulsification (a sleeveless phaco tip) and infusion (an irrigating chopper). Recently, coaxial phacoemulsification through 1.8 mm incisions called microcoaxial cataract surgery (C-MICS) has been introduced. It has been documented in previous studies that the location[13] and size[2,4] of the corneal incision and type of the intraocular lens[14] determine corneal aberration changes following cataract surgery.

Several studies report that MICS has advantages over conventional cataract surgery in reducing both SI astigmatism and SI corneal HOAs,[2,4,12] whereas some authors describe no significant difference between MICS and conventional surgery with respect to generating HOAs.[3] Based on the varying results in previous studies, there is a controversy over whether MICS induces same amount of HOAs as conventional surgery or induces no significant HOA. And also, to our knowledge, there is no study, which compares two MICS techniques in terms of SI HOAs. The aim of this study was to evaluate whether both MICS techniques modify corneal HOA formation following surgery and to compare the effects of two techniques on the optical quality of the cornea.

PATIENTS AND METHODS

This prospective randomized study comprised 80 eyes of 60 patients having uneventful microincision cataract surgery. 40 eyes of 28 patients were operated with B-MICS through 1.2–1.4 mm trapezoidal clear corneal incisions (Group 1) and 40 eyes of 32 patients with C-MICS technique through 1.8 mm clear corneal incisions (Group 2).

Patients having a history of ocular disease, previous intraocular surgery including corneal laser treatment, astigmatism higher than 1.50 D and corneal pathology disrupting the clarity of the cornea and any complications during surgery were not included in this study.

Cataract density of the patients was evaluated according to LOCS III[15] and eyes having grade 2–4 nuclear or corticonuclear cataracts were included in this study. The study was in accordance with the tenets of the Declaration of Helsinki (World Medical Association Declaration of Helsinki. Ethical principles for medical research involving human subjects. Edinburgh, Scotland, 52nd general assembly, October 2000. Available at: http://www4.ensp.fiocruz.br/etica/docs/artigos/ Helsinq.pdf. Accessed November 2, 2010) and all patients provided informed consent.

Detailed examinations including refraction, uncorrected and corrected visual acuity (Snellen chart), anterior and posterior segment evaluation, intraocular pressure with applanation tonometry were performed and corneal topography of the eyes were taken (Keratron Scout Corneal Analyzer Optikon 2000, Italy) before surgery and 1 month postoperatively. Contrast sensitivity function with and without glare was evaluated (CVS 1000E, Vector Vision Co., Ohio) at 1 month.

Surgical Technique

All of the operations were performed by the same surgeon (İ.C.) under topical anesthesia with Stellaris phacoemulsification system (Bausch & Lomb Inc., Rochester, NY) with venturi pump.

B-MICS technique was performed through two 90–110° apart similar trapezoidal 1.2–1.4 mm incisions using a 19-gauge steel knife (EdgeAheadT, (#585240) BD Medical Sys, UT), and in the C-MICS group main incisions were created with a 1.6–1.8 mm trapezoidal knife (Laseredge trapezoidal knife (# E7600) (Bausch & Lomb Inc.) on the corneal steep axes. After capsulorrhexis, phacoemulsification was carried out in accordance to our previously described "Half moon supracapsular phacoemulsification" technique[16] in both groups. While a sleeveless 30˚, straight thin phaco tip (0.90 mm outer and 0.67 mm inner diamater) (Bausch & Lomb Inc.), 20 G. Fine-Nagahara irrigating chopper (MST, Redmont, WA) and Duet set cannula (MST) were used for B-MICS, a sleeved 30˚, straight propriety design tip (0.95 mm outer and 0.79 mm inner diamater) (Bausch & Lomb Inc.), Chang's microfinger chopper (Katena Instruments, Katena Products, Inc, Denville, New Jersey, USA), and bimanual I/A set (Alcon Laboratories Inc. Alcon Labs, Forthworth, Texas, USA) for C-MICS operations. Surgeries were performed with identical phacoemulsification paramaters in both groups. (350 mmHg linear vacuum, 50% power, micropulse mode (20/40) and 130 cm bottle height).

In the B-MICS group, one of the incisions that is on the corneal steep axis was enlarged to 1.8 mm with a 1.6–1.8 mm trapezoidal knife (Laseredge trapezoidal knife (# E7600) (Bausch & Lomb Inc.) before implantation of the IOL. Then Akreos MI-60 (Bausch & Lomb Inc.) intraocular lenses were implanted with Viscoject lens injection system (LP604350, Medicel AG, Swe) in both groups. Incision widths were measured with a Tsuneoka microincision gauge (American Surgical Instruments Corp ASICO, Westmont, Illinois, USA) after IOL implantation.

Corneal Wavefront Aberrations

All the patients had corneal topography (Keratron Scout Corneal Analyzer Optikon 2000, Italy) preoperatively and 1 month postoperatively. Keratron Scout enables the evaluation of 85–90% of the corneal surface with its placido-type small cone and 28 rings. This device creates the corneal wavefront map using real elevation maps instead of keratometric data. Measurements of corneal elevation and distortion are stated to be as accurate as 1 µm. The software calculates the corneal wavefront and then converts the elevation data into Zernike polynomials. In our study corneal aberrations were derived by converting the corneal elevation profile into corneal wavefront data with a 6.0 mm aperture diameter. For each eye, the mean of 3 measurements at a 6.0 mm diameter central area with respect to the pupil center was calculated and used as the final estimate of the aberration measurements.

The root mean square (RMS) of higher order aberrations (HOAs) (RMS value of 3rd to 6th Zernike modes), total RMS, astigmatism ($Z_2^{\pm 2}$), primary coma ($Z_3^{\pm 1}$), primary trefoil ($Z_3^{\pm 3}$), spherical aberration (Z_4^0) were calculated from corneal wavefront data. The amount of SI astigmatism was calculated from corneal topography data using vector analysis method described by Holladay et al.[17] based on the simulated keratometry readings obtained from corneal topography. Induced aberrations were obtained as the vectorial magnitude of the difference between postoperative and preoperative aberrations. In the case of the nonrotationally symmetric aberrations (astigmatism, coma and trefoil), both the magnitude and orientation of the induced aberrations were obtained. The percentages of the axes within ±20° of main incision site were calculated for SI astigmatism, induced coma and trefoil after performing the adequate rotation according to the symmetry of astigmatism and trefoil (180° and 120°, respectively). For astigmatism β and β + 180° correspond to same axis (e.g. 90° = 270°). In case of trefoil, the axis goes from 0° to 120° because of the symmetry of this aberration, which has three lobules spaced at 120°. In other words, β, β + 120°, and β + 240° correspond to the same axis for trefoil (e.g. 0° = 120° = 240°).

TABLE 1 Patients' demographics and preoperative characteristics.

Parameter	B-MICS	C-MICS	*p*
Eyes/patients (*n*)	40/28	40/32	–
Sex (male/female)	16/12	17/15	0.555*
Laterality (right/left)	20/20	20/20	–
Mean age (y) ± SD	65.29 ± 8.24	63.59 ± 11.77	0.656**
Δ SimK (D)	0.68 ± 0.34	0.72 ± 0.43	0.565**
Mean BCVA ± SD			
Snellen	0.36 ± 0.18	0.29 ± 0.22	0.239**
LogMAR	0.53 ± 0.36	0.67 ± 0.40	

B-MICS: biaxial microincisional cataract surgery; C-MICS: microcoaxial cataract surgery; Δ SimK: the difference in power between the steep and flat meridians; BCVA: best corrected visual acuity.
*χ^2-test, **independent samples *t* test.

TABLE 2 Intraoperative data.

	B-MICS	C-MICS	*p**
Effective phaco time (sec)	5.11 ± 2.22	6.25 ± 3.18	0.151
Mean fluid used (mL)	111.75 ± 32.12	107.66 ± 30.90	0.812
Total operation time (min)	15.49 ± 3.36	14.19 ± 3.08	0.195
Final main incision width (mm)	1.80 ± 0.09	1.89 ± 0.11	0.062
IOL power (D)	21.73 ± 1.68	22.41 ± 1.92	0.215

B-MICS: biaxial microincisional cataract surgery; C-MICS: microcoaxial cataract surgery.
*Independent samples *t* test.

Statistical Analysis

Statistical analysis was performed using SPSS for Windows software (version 16.0, SPSS, Inc., Chicago, Illinois, USA). The χ^2-test, paired samples *t* test and independent samples *t* test were used for comparisons. The evaluations were completed with 95% reliability and $p < 0.05$ was accepted to be significant.

RESULTS

There was no statistically significant difference between groups in age, sex, laterality, corneal astigmatism and BCVA values preoperatively (Table 1). Corneal astigmatism was measured using the change in simulated keratometry (Δ Sim K) values, the difference in power between the steep and flat meridians, which were obtained from the topographer. Table 2 shows the intraoperative data. The mean final incision width was smaller in the B-MICS group than in the C-MICS group, the difference was at the limit of statistical significance ($p = 0.062$).

While the mean postoperative BCVAs were 0.91 ± 0.15 (LogMAR:0.04 ± 0.09) in Group 1 and 0.90 ± 0.22 (LogMAR:0.08 ± 0.21) in Group 2 ($p = 0.921$), the mean Δ SimK value was 0.79 ± 0.27 D and 0.84 ± 0.26 D ($p = 0$ 0.445) in Groups 1 and 2, respectively.

Corneal Wavefront Aberrations

Preoperative corneal wavefront aberrations were not different between the groups. In the B-MICS group all aberration terms were similar, before and after surgery. However, in the C-MICS group vertical coma (Z_3^{-1}) ($p = 0.002$) and vertical trefoil (Z_3^{-3}) ($p < 0.001$) significantly increased postoperatively.

Table 3 shows the mean preoperative and postoperative corneal aberrations over a 6.0 mm area centered on the pupil for Zernike terms from the 2nd to 4th order. There was no statistical difference in total and HO RMS values in both groups, postoperatively. Coma slightly decreased in the biaxial group, on the contrary it increased in the microcoaxial group. Trefoil increased in both groups postoperatively, but the change was statistically significant only in Group 2. The mean astigmatism slightly increased in both groups, whereas spherical aberration slightly decreased following surgery; the changes were not statistically significant (Table 4). The change of corneal aberrations for 6 mm pupil diameters in the B-MICS and C-MICS groups are shown in Figure 1A and B, respectively.

SI aberrations and their relation with the incision sites can be seen in the Table 5. Except SI trefoil ($p = 0.047$), there was no significant difference in all SI corneal aberrations between groups. Most patients in both groups

TABLE 3 Mean preoperative and postoperative corneal Zernike terms.

	B-MICS			C-MICS		
	Preoperative	Postoperative	*p**	Preoperative	Postoperative	*p**
Z(2,–2)	–0.195 ± 0.475	–0.245 ± 0.508	0.676	0.051 ± 0.348	0.040 ± 0.468	0.902
Z(2, 2)	0.0613 ± 0.524	0.139 ± 0.546	0.530	–0.129 ± 0.714	–0.265 ± 0.610	0.101
Z(3,–1)	0.176 ± 0.303	0.044 ± 0.350	0.217	0.098 ± 0.363	–0.121 ± 0.344	**0.002**
Z(3, 1)	0.092 ± 0.416	0.005 ± 0.033	0.062	–0.050 ± 0.423	0.023 ± 0.448	0.324
Z(3,–3)	–0.151 ± 0.081	–0.196 ± 0.193	0.623	–0.097 ± 0.156	–0.269 ± 0.190	**<0.001**
Z(3, 3)	0.017 ± 0.212	–0.015 ± 0.066	0.585	0.027 ± 0.214	–0.067 ± 0.208	0.060
Z(4,–2)	–0.003 ± 0.073	–0.003 ± 0.089	0.998	–0.007 ± 0.120	–0.005 ± 0.169	0.845
Z(4, 2)	0.0815 ± 0.188	–0.038 ± 0.130	0.177	–0.005 ± 0.176	–0.325 ± 0.254	0.427
Z(4,–4)	–0.003 ± 0.196	0.002 ± 0.198	0.921	0.015 ± 0.184	0.015 ± 0.177	0.996
Z(4, 4)	–0.039 ± 0.192	–0.009 ± 0.202	0.385	0.002 ± 0.153	0.020 ± 0.218	0.644

B-MICS: biaxial microincisional cataract surgery; C-MICS: microcoaxial cataract surgery.
*Paired samples *t* test.

TABLE 4 Preoperative and postoperative wavefront aberrations in groups.

B-MICS				C-MICS			
Aberrations	Preoperative	Postoperative	*p**	Aberrations	Preoperative	Postoperative	*p**
Total RMS	1.102 ± 0.303	1.127 ± 0.266	0.779	Total RMS	1.138 ± 0.517	1.171 ± 0.395	0.665
HO RMS	0.557 ± 0.152	0.572 ± 0.145	0.574	HO RMS	0.584 ± 0.296	0.683 ± 0.207	0.088
Astigmatism	0.670 ± 0.282	0.694 ± 0.317	0.709	Astigmatism	0.637 ± 0.389	0.690 ± 0.426	0.269
Coma	0.491 ± 0.216	0.433 ± 0.187	0.272	Coma	0.486 ± 0.163	0.525 ± 0.218	0.156
Trefoil	0.240 ± 0.105	0.285 ± 0.285	0.778	Trefoil	0.249 ± 0.132	0.358 ± 0.157	**0.042**
Spherical Aberration	0.295 ± 0.127	0.272 ± 0.118	0.523	Spherical Aberration	0.250 ± 0.193	0.218 ± 0.158	0.372

B-MICS: biaxial microincisional cataract surgery; C-MICS: microcoaxial cataract surgery.
*Paired samples *t* test.
RMS: root mean square; HO: higher order.

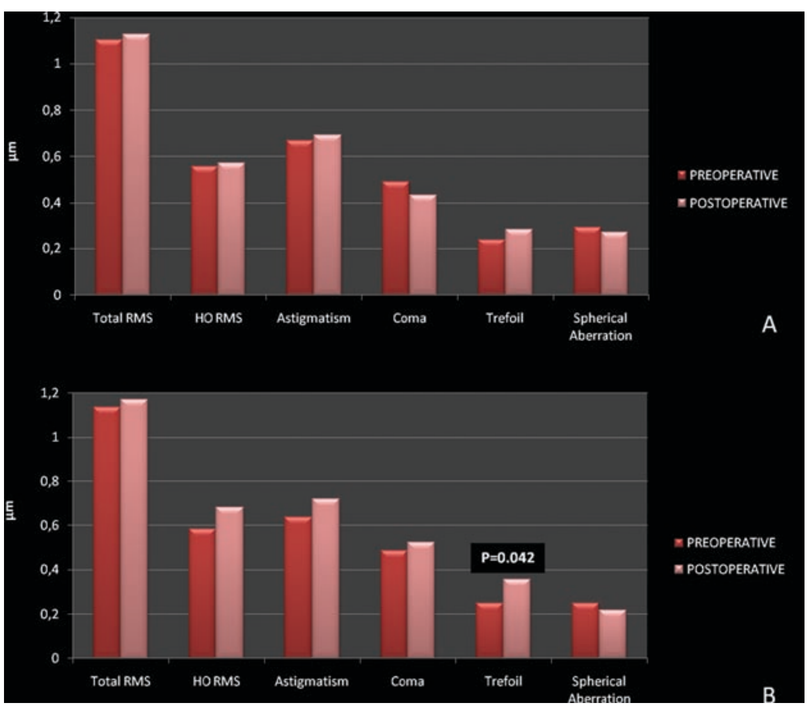

FIGURE 1 Preoperative and postoperative RMS values of corneal aberrations (A) biaxial microincision cataract surgery (B-MICS) group, (B) microcoaxial cataract surgery (C-MICS) group.

TABLE 5 Surgically induced astigmatism and higher order aberrations.

	B-MICS	C-MICS	*p**
SI Astigmatism (D) (Vector Analysis Method)	0.23 ± 0.32 (25% have an axes within ± 20° of the incision site)	0.26 ± 0.42 (27.5% have axes within ± 20° of the incision site)	0.874
SI Spherical Aberration	0.006 ± 0.161	–0.031 ± 0.211	0.502
SI Coma	0.319 ± 0.255 (10% have axes within ± 20° of the incision site)	0.376 ± 0.229 (12.5% have axes within ± 20° of the incision site)	0.109
SI Trefoil	0.306 ± 0.211 (42.5% have axes within ± 20° of the incision site)	0.451 ± 0.229 (57.5% have axes within ± 20° of the incision site)	**0.047**

B-MICS: biaxial microincisional cataract surgery; C-MICS: microcoaxial cataract surgery; SI: surgically induced.
*Paired samples *t* test.

TABLE 6 Contrast sensitivity results with and without glare.

	B-MICS	C-MICS	*p**
		Without Glare	
3 cpd	1.62 ± 0.30	1.58 ± 0.18	0.694
6 cpd	1.87 ± 0.22	1.79 ± 0.19	0.462
12 cpd	1.57 ± 0.27	1.43 ± 0.13	0.321
18 cpd	1.16 ± 0.29	1.25 ± 0.24	0.591
		With Glare	
3 cpd	1.59 ± 0.21	1.53 ± 0.25	0.620
6 cpd	1.77 ± 0.23	1.72 ± 0.23	0.683
12 cpd	1.48 ± 0.24	1.31 ± 0.29	0.210
18 cpd	1.11 ± 0.27	1.29 ± 0.25	0.427

*Independent samples *t* test.
cpd: cycles per degree.

had a predominant axis of SI trefoil along the incision site; which was more evident in the C-MICS group. The axes of SI astigmatism and coma were not related to the incision site.

There were no significant differences between groups in contrast sensitivity measurements evaluated in the first postoperative month (Table 6).

DISCUSSION

Optical properties of the corneal surface have a great impact on retinal image since about 80% of all aberrations of the human eye occur in the corneal surface.[18] Corneal incisions can alter corneal surface during cataract surgery and increase aberrations which degrade optical quality of the cornea. Increased corneal and IOL induced aberrations following surgery may cause dissatisfaction in patients who have a good visual acuity but decreased functional vision. Size and location of the incision have the greatest impact on SI corneal aberrations. It has been reported that the smaller the incision size, the lower the SI astigmatism and the corneal aberrations are.[2,4,19] This gave rise to a trend to complete surgery with smaller incisions.

Many studies show that SI astigmatism is almost zero with MICS.[2,20–24] In the current study, SI astigmatism with both techniques (0.23 ± 0.32 D and 0.26 ± 0.42 D, respectively) agree with 0.36 ± 0.23 D that Alio et al.[2] found with MICS and less than –1.0 ± 0.90 D found with small incision cataract surgery in a previous study.[5] We also found that the axes of SI astigmatism in both groups were independent from surgical incision in any direction. This also supports that MICS offers an astigmatically neutral incision.

While 2.0 mm incision sizes were reported[19] as the limit for providing astigmatically neutral results, the situation seems to be different for HOAs. Tong et al.[25] declared an increase in corneal trefoil following B-MICS, whereas Nochez et al.[26] indicated a significant change in vertical trefoil after C-MICS surgery with 1.8 mm incisions. In our study, corneal astigmatism and trefoil were found increased after B-MICS, but not significantly. However, in the C-MICS group, the postoperative increase in trefoil was statistically significant. There was a significant increase in vertical trefoil in addition to the significant increase in vertical coma after C-MICS. SI trefoil was significantly different between the two groups ($p = 0.047$).

Trefoil, also known as the triangular astigmatism, has a position close to the altitude of the Zernike pyramid and its order is relatively low. Therefore, like astigmatism, coma and spherical aberrations, which have relatively low orders, trefoil affects vision more than the aberrations having a higher order.[27]

The axes of SI trefoil in C-MICS group were found mostly relevant to the incision site in the current study. When commenting about this relationship and deciding which MICS technique is advantageous, it is crucial to evaluate incision site quality. We know from our recent study[28] that there were no meaningful differences between the clear corneal incisions of these techniques based on anterior segment optical coherence tomography examinations. If incision site damage or quality is indifferent, incision size should be taken into consideration as a remaining factor. Although our aim was to complete surgeries with a final 1.80 mm incision width in both groups, this study eventuated with larger final incisions in the C-MICS group (1.89 mm vs. 1.80 mm) and the difference between the groups was at the limit of statistical significance ($p = 0.062$). In our study, identical IOLs were implanted to limit bias, however during cataract surgery incision enlargement may have occurred even before IOL implantation.[29,30] So, a possible explanation of slightly larger final incision widths in the C-MICS group might be stretching of the wound margins with sleeved phaco tip during phacoemulsification through 1.8 mm main incision. Whereas, in the B-MICS group, enlargement of main incision to 1.8 mm was performed after phaco procedure, just before IOL implantation. Our results also indicate that the enlargement of incisions for IOL implantation with B-MICS does not have an effect on corneal aberrations. In addition, in our study there were 2 incisions in the cornea in the B-MICS group whereas there were 3 incisions in the C-MICS group. Having a third incision on the corneal plane may contribute to trefoil formation as well.

One other aspect of the issue is the possible effect of incision location. Jiang et al.[31] reported that a clear corneal incision placed on the steepest meridian induces less astigmatism and less corneal HOAs including corneal coma, trefoil and secondary coma. In our study main incisions were already placed on the steepest meridians in both groups. Thus the difference between the two groups with respect to induced trefoil cannot be attributed to the site of the incisions. So we believe one more time that the difference in the final incision size was the most important factor in this SI aberration formation.

Final retinal image of the pseudophakic eye is determined by a combination of corneal and internal aberrations generated by the IOL and those induced by surgery. Protection of the optical quality of the cornea and minimum alteration of corneal aberrations during surgery has an additional advantage with IOLs that were designed to correct aberrations. Aspheric monofocal and multifocal IOLs work under the assumption that spherical aberration remains practically unchanged after surgery. Previous studies showed that conventional cataract surgery increases HOAs.[5,14] We found that neither total RMS nor HO RMS significantly increased postoperatively with both MICS surgery techniques. Also, they do not induce significant changes in astigmatism and spherical aberration. These results were compatible with those reported by Elkady et al.[12] Our results are promising for the customized IOL concept with an aberration profile manufactured based on preoperative data.

The term “functional vision” describes the impact of sight on quality of life. Driving at night, reading, performing professional tasks all bring a relation to functional vision. Contrast sensitivity function, measured under varying conditions of luminance and glare, establishes the limits of visual perception across the spectrum of spatial frequencies.[32,33] HOAs such as spherical aberration and coma have an impact on contrast sensitivity and visual clarity.[6,27,34] In that respect, postoperative contrast sensitivity measurements with and without glare were within normal levels with both techniques which indicates that both techniques yield good functional vision (Table 6).

The goal of modern cataract surgery is to improve the visual quality of pseudophakic patients. Generally it is supposed that smaller incisions are preferred to minimize SI astigmatism; however incision sizes and locations are effective factors for developing corneal HOAs as well. In this study to minimize the SI aberrations, we performed MICS with implantation of an aspheric aberration free IOL. We found no significant changes in the total RMS, HO RMS, primary coma, spherical aberration and astigmatism postoperatively in both groups. Both microincision surgery techniques do not degrade the optical quality of the cornea so have an advantage over conventional surgery. However it is hard to explain why vertical coma, vertical trefoil and primary trefoil have increased significantly in the microcoaxial group whereas there was no change in the biaxial group.

The first possible reason causing this result is the 0.09 mm difference in the final incision widths between groups. However the difference was not statistically significant, which makes this interpretation difficult. The other possible reasons might be fewer side port incisions with B-MICS technique or different healing process of wound architecture due to surgical technique. We think that additional studies with larger series are needed to answer these questions and clarify the other probable reasons.

ACKNOWLEDGMENTS

None of the authors has a financial and proprietary interest in any material or method mentioned and there is no public or private support. Presented as free paper at the ASCRS Symposium, San Diego, CA, USA, March 2011. This article has not been published elsewhere and that it has not been submitted simultaneously for publication elsewhere.

***Declaration of interest*:** The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

REFERENCES

[1] Hayashi K, Yoshida M, Hayashi H. Correlation of higher-order wavefront aberrations with visual function in pseudophakic eyes. *Eye (Lond).* 2008;22:1476–1482.

[2] Alió J, Rodríguez-Prats JL, Galal A, Ramzy M. Outcomes of microincision cataract surgery versus coaxial phacoemulsification. *Ophthalmology.* 2005;112:1997–2003.

[3] Yao K, Tang X, Ye P. Corneal astigmatism, high order aberrations, and optical quality after cataract surgery: microincision versus small incision. *J Refract Surg.* 2006;22:S1079–S1082.

[4] Denoyer A, Denoyer L, Marotte D, Georget M, Pisella PJ. Intraindividual comparative study of corneal and ocular wavefront aberrations after biaxial microincision versus coaxial small-incision cataract surgery. *Br J Ophthalmol.* 2008;92:1679–1684.

[5] Guirao A, Tejedor J, Artal P. Corneal aberrations before and after small-incision cataract surgery. *Invest Ophthalmol Vis Sci.* 2004;45:4312–4319.

[6] Applegate RA, Hilmantel G, Howland HC, Tu EY, Starck T, Zayac EJ. Corneal first surface optical aberrations and visual performance. *J Refract Surg.* 2000;16:507–514.

[7] Chalita MR, Xu M, Krueger RR. Correlation of aberrations with visual symptoms using wavefront analysis in eyes after laser in situ keratomileusis. *J Refract Surg.* 2003;19:S682–S686.
[8] Holladay JT. Optical quality and refractive surgery. *Int Ophthalmol Clin.* 2003;43:119–136.
[9] Cavallini GM, Campi L, Masini C, Pelloni S, Pupino A. Bimanual microphacoemulsification versus coaxial miniphacoemulsification: prospective study. *J Cataract Refract Surg.* 2007;33:387–392.
[10] Tsuneoka H, Shiba T, Takahashi Y. Ultrasonic phacoemulsification using a 1.4 mm incision: clinical results. *J Cataract Refract Surg.* 2002;28:81–86.
[11] Soscia W, Howard JG, Olson RJ. Bimanual phacoemulsification through 2 stab incisions. A wound-temperature study. *J Cataract Refract Surg.* 2002;28:1039–1043.
[12] Elkady B, Alió JL, Ortiz D, Montalbán R. Corneal aberrations after microincision cataract surgery. *J Cataract Refract Surg.* 2008;34:40–45.
[13] Pesudovs K, Dietze H, Stewart OG, Noble BA, Cox MJ. Effect of cataract surgery incision location and intraocular lens type on ocular aberrations. *J Cataract Refract Surg.* 2005;31:725–734.
[14] Marcos S, Rosales P, Llorente L, Jiménez-Alfaro I. Change in corneal aberrations after cataract surgery with 2 types of aspherical intraocular lenses. *J Cataract Refract Surg.* 2007;33:217–226.
[15] Chylack LT Jr, Wolfe JK, Singer DM et al. The Lens Opacities Classification System III. The Longitudinal Study of Cataract Study Group. *Arch Ophthalmol.* 1993;111:831–836.
[16] Can I, Takmaz T, Genç I. Half-moon supracapsular nucleofractis phacoemulsification: safety, efficacy, and functionality. *J Cataract Refract Surg.* 2008;34:1958–1965.
[17] Holladay JT, Moran JR, Kezirian GM. Analysis of aggregate surgically induced refractive change, prediction error, and intraocular astigmatism. *J Cataract Refract Surg.* 2001; 27:61–79.
[18] Hamam H. A new measure for optical performance. *Optom Vis Sci.* 2003;80:175–184.
[19] Alió JL, Elkady B, Ortiz D. Corneal Optical Quality Following Sub 1.8 mm Micro-Incision Cataract Surgery vs. 2.2 mm Mini-Incision Coaxial Phacoemulsification. *Middle East Afr J Ophthalmol.* 2010;17:94–99.
[20] Can I, Takmaz T, Yildiz Y, Bayhan HA, Soyugelen G, Bostanci B. Coaxial, microcoaxial, and biaxial microincision cataract surgery: prospective comparative study. *J Cataract Refract Surg.* 2010;36:740–746.
[21] Hayashi K, Yoshida M, Hayashi H. Postoperative corneal shape changes: microincision versus small-incision coaxial cataract surgery. *J Cataract Refract Surg.* 2009;35:233–239.
[22] Kaufmann C, Krishnan A, Landers J, Esterman A, Thiel MA, Goggin M. Astigmatic neutrality in biaxial microincision cataract surgery. *J Cataract Refract Surg.* 2009;35:1555–1562.
[23] Kurz S, Krummenauer F, Gabriel P, Pfeiffer N, Dick HB. Biaxial microincision versus coaxial small-incision clear cornea cataract surgery. *Ophthalmology.* 2006;113:1818–1826.
[24] Wilczynski M, Supady E, Piotr L, Synder A, Palenga-Pydyn D, Omulecki W. Comparison of surgically induced astigmatism after coaxial phacoemulsification through 1.8 mm microincision and bimanual phacoemulsification through 1.7 mm microincision. *J Cataract Refract Surg.* 2009;35:1563–1569.
[25] Tong N, He JC, Lu F, Wang Q, Qu J, Zhao YE. Changes in corneal wavefront aberrations in microincision and small-incision cataract surgery. *J Cataract Refract Surg.* 2008;34:2085–2090.
[26] Nochez Y, Majzoub S, Pisella PJ. Corneal aberration integrity after microincision cataract surgery: prerequisite condition for prediction of total ocular aberrations. *Br J Ophthalmol.* 2010;94:661–663.
[27] Applegate RA, Sarver EJ, Khemsara V. Are all aberrations equal? *J Refract Surg.* 2002;18:S556–S562.
[28] Can I, Bayhan HA, Celik H, Bostanci Ceran B. Anterior segment optical coherence tomography evaluation and comparison of main clear corneal incisions in microcoaxial and biaxial cataract surgery. *J Cataract Refract Surg.* 2011;37:490–500.
[29] Kohnen T, Klaproth OK. Incision sizes before and after implantation of SN60WF intraocular lenses using the Monarch injector system with C and D cartridges. *J Cataract Refract Surg.* 2008;34:1748–1753.
[30] Espiritu CR, Bernardo JP Jr. Incision sizes at different stages of phacoemulsification with foldable intraocular lens implantation. *J Cataract Refract Surg.* 2009;35:2115–2120.
[31] Jiang Y, Le Q, Yang J, Lu Y. Changes in corneal astigmatism and high order aberrations after clear corneal tunnel phacoemulsification guided by corneal topography. *J Refract Surg.* 2006;22:S1083–S1088.
[32] Ginsburg AP, Evans DW, Sekule R, Harp SA. Contrast sensitivity predicts pilots' performance in aircraft simulators. *Am J Optom Physiol Opt.* 1982;59:105–109.
[33] Lord SR, Dayhew J. Visual risk factors for falls in older people. *J Am Geriatr Soc.* 2001;49:508–515.
[34] Applegate RA, Howland HC, Sharp RP, Cottingham AJ, Yee RW. Corneal aberrations and visual performance after radial keratotomy. *J Refract Surg.* 1998;14:397–407.