Corneal Astigmatism, High Order Aberrations, and Optical Quality After Cataract Surgery: Microincision Versus Small Incision

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ABSTRACT

PURPOSE: To compare the astigmatism, high order aberrations, and optical quality of the cornea after microincision (~1.7 mm) versus small incision (~3.2 mm) cataract surgery at Eye Center, Zhejiang University, Hangzhou, China.

METHODS: This prospective, randomized clinical study included microincision cataract surgery and small incision cataract surgery performed on 60 eyes. Corneal astigmatism and higher order aberrations to the sixth order were measured using the NIDEK OPD-Scan aberrometer/topographer 1 month after surgery. To evaluate the optical quality of the cornea, the 0.5 modulation transfer function (MTF) value and 0.1 MTF value within a 5-mm pupil were calculated using OPD-Station software. Statistical analysis assessing the difference between groups was carried out using the independent *t* test.

RESULTS: The mean corneal astigmatism was significantly lower after microincision cataract surgery compared with small incision cataract surgery (0.78±0.38 diopters [D] vs 1.29±0.68 D, respectively; P=.001). No significant differences were found between the two groups for the root-mean-square value of total high order aberrations or individual high order aberrations for spherical aberration, coma, and trefoil. However, eyes that underwent microincision cataract surgery showed statistically significantly better optical performance with a 0.5 MTF value than eyes that underwent small incision cataract surgery (3.13±0.30 cycles per degree [cpd] vs 2.75±0.63 cpd, respectively; P=.005). The 0.1 MTF values for the two groups were 9.37±3.72 cpd for microincision cataract surgery and 7.24±3.43 cpd for small incision cataract surgery, which was not significantly different (P=.136).

CONCLUSIONS: Microincision cataract surgery generates statistically significantly less corneal astigmatism and better optical quality of the cornea by MTF evaluation compared with small incision cataract surgery. However, microincision cataract surgery shows no significant advantage in reducing corneal high order aberrations over small incision cataract surgery. [*J Refract Surg*. 2006;22:S1079-S1082.]

The human eye is a complex structure, and each of its elements contributes to visual function. Degraded optical performance of the cornea after incisional cataract surgery would limit the visual quality of the pseudophakic eye. In conventional, coaxial phacoemulsification, or small incision cataract surgery, anterior chamber infusion is supplied through a flexible silicone sleeve surrounding the phaco needle. Typical phaco tips have diameters of approximately 1 mm. Coaxial systems, which are used in traditional small incision cataract surgery, require corneal incisions ranging from 2.5 to 3.2 mm to accommodate infusion sleeves large enough to provide adequate inflow. Although these incisions are smaller compared with those in earlier techniques, they are still large enough to increase corneal astigmatism and induce aberrations that degrade the optical quality of the cornea.[1-3]

The improvements in ultrasound technology, phaco instrumentation, and new intraocular lens (IOL) materials have accompanied the evolution of new surgical techniques, resulting in the development of microincision cataract surgery.[4] Microincision cataract surgery was defined as cataract surgery performed through a <2-mm incision using a bimanual technique. In bimanual microincision cataract surgery, anterior chamber infusion is accomplished with an instrument separate from the phacoemulsification/aspiration unit. Ultrasound power is provided by a sleeveless, bare phaco needle on a standard handpiece with the irrigation port capped. The infusion line is connected to a second instrument, usually a 19- or 20-gauge irrigating chopper, which provides fluid inflow and assists in nuclear manipulation. Each instrument is inserted through clear corneal incisions of approximately 0.9 to 1.5 mm. In addition, the advent of newer IOL technology has made it possible to inject an IOL through an incision >1.5 mm. Advanced microincision cataract surgery may have

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TABLE 1

Preoperative Data of 60 Eyes That Underwent Microincision or Small Incision Cataract Surgery

Demographic	Microincision	Small Incision	*P* Value
No. patients (eyes)	30	30	
Age (y)	70.07±10.89	71.20±9.05	.815
ΔSimK (D)	0.70±0.34	0.66±0.38	.669
Corneal power (D)	44.89±1.44	44.32±1.27	.710

Note. *ΔSimK denotes the difference in power between the steep and flat meridians.*

some advantages over coaxial small incision cataract surgery, such as inducing less astigmatism, improving anterior chamber stability, and reducing the incidence of endophthalmitis.

Although the outcomes of microincision cataract surgery have been reported by many authors,[5,6] no studies have evaluated the postoperative corneal properties and optical quality after microincision cataract surgery compared with small incision cataract surgery. This study assesses the potential advantages of microincision cataract surgery over small incision cataract surgery in reducing astigmatism, aberrations, and improving optical quality of the cornea after surgery.

PATIENTS AND METHODS

Sixty eyes from patients scheduled for cataract surgery were randomly assigned to undergo microincision cataract surgery (group 1) or coaxial small incision cataract surgery (group 2). Patient inclusion criterion was the presence of a visually significant cataract. Patient exclusion criteria for the study were a history of ocular surgery including laser surgery, corneal disease, ocular media opacification other than cataract, and retinal disease. All clinical examinations and surgeries were conducted at Eye Center, Affiliated Second Hospital of Zhejiang University, Hangzhou, China. The same surgeon performed all surgeries, and an independent ophthalmologist who did not perform any of the surgeries in this study conducted follow-up. Data from 1-month postoperative follow-up are presented.

SURGICAL TECHNIQUE

Surgery was performed under topical or retrobulbar anesthesia. In microincision cataract surgery, two microincisions, each 1.5-mm long, were created on the superior cornea. One incision was an irrigation channel and the other an aspiration channel. Once the anterior chamber was filled with viscoelastic material, a capsulorrhexis was performed using microincision cataract surgery capsulorrhexis forceps. After hydrodissection, manual prechopping was performed using the microincision cataract surgery prechoppers, followed by low ultrasound phacoemulsification. The residual cortex was eliminated and posterior capsule cleaning performed at the end. Prior to IOL implantation, the capsular bag was filled with viscoelastic material. The IOLs were implanted using an injection system through a 1.6- to 1.8-mm incision.

For small incision cataract surgery, a 3.2-mm clear corneal tunnel incision was created superiorly, and the side puncture was made at the 2-o'clock position. After the capsulorrhexis was completed, hydrodissection, nucleus rotation, and prechopping were performed using a technique similar to that used in group 1. Phacoemulsification was carried out using the "divide-and-conquer" or "stop-and-chop" technique. Finally, the cortex was aspirated with an irrigation/aspiration tip, the IOL implanted, and the viscoelastic removed at the end surgery.

CORNEAL ASTIGMATISM AND OPTICAL QUALITY EVALUATION

Corneal topography, wavefront aberrations, and modulation transfer function (MTF) were measured to evaluate the corneal properties and optical performance after microincision cataract surgery or small incision cataract surgery. The measurement was carried out using the NIDEK OPD-Scan aberrometer and topographer equipped with the OPD-Station software, version 1.02 (NIDEK Co Ltd, Gamagori, Japan). The OPD-Scan device is an aberrometer that uses dynamic skiascopy, an automated form of retinoscopy, to measure the aberrations of the eye. The OPD-Scan plots the total aberrations of the eye, corneal aberrations, and internal aberrations. In addition, the capability of this instrument to measure normal to extremely aberrated eyes made it the instrument of choice for this investigation. The integrated corneal topographer provides a number of corneal topography maps that allow extensive evaluation of the cornea. The OPD-Station software allows isolation of corneal or internal aberrations and total aberration to determine the effect of each optical component of the eye on visual function and quality. The OPD-Station software can simulate MTF and plot MTF graphs using the Holladay Summary. In this study, corneal astigmatism was measured using the change in simulated keratometry (ΔSimK) values, the difference in power between the steep and flat meridians, which were obtained from the OPD-Scan. Corneal wavefront aberration to the sixth order and a 5-mm optical zone of the cornea were analyzed. The spatial frequencies at 0.5 MTF and 0.1 MTF of the cor-

TABLE 2

Wavefront Error Values (μm) of Corneal High Order Aberrations After Microincision Cataract Surgery and Small Incision Cataract Surgery Measured to the Sixth Order for a 5-mm Pupil Size

Cataract Surgery	HOA	Total Sphere	Total Coma	Total Trefoil	Total Quadrafoil
Microincision	2.04±1.23	0.26±0.23	0.85±0.68	1.30±0.95	0.74±0.52
Small incision	1.80±0.87	0.28±0.23	0.67±0.38	1.06±0.63	0.80±0.50
P value	.408	.680	.260	.265	.645

Note. High order aberration (HOA) denotes total higher order aberration excluding lower order aberrations such as sphere and cylinder.

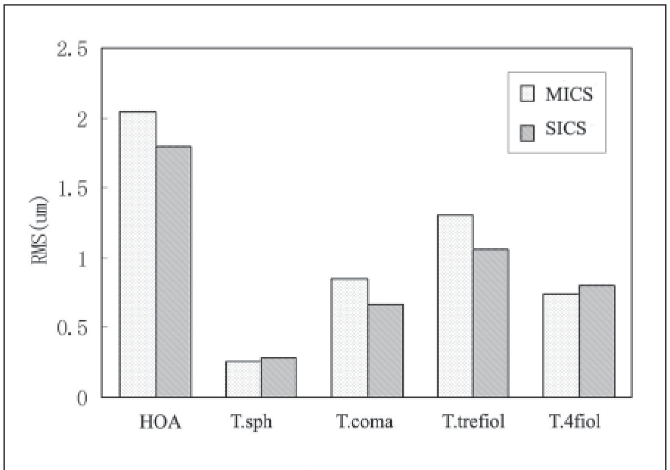

Figure 1. Corneal high order aberrations following microincision cataract surgery (MICS) performed through an ~1.7-mm incision and small incision cataract surgery (SICS) performed through an ~3.2-mm incision.

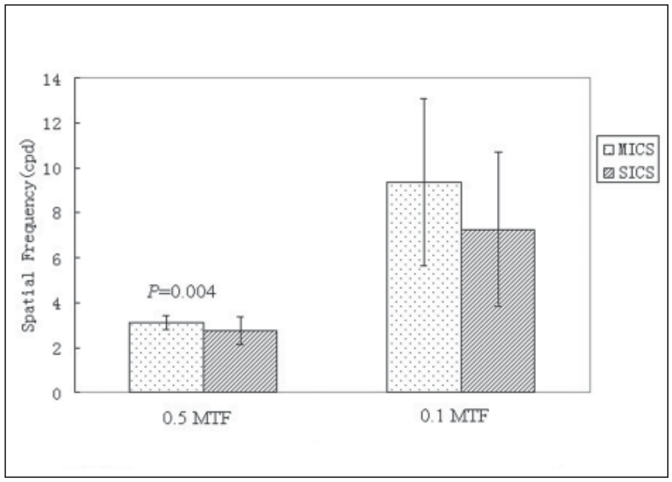

Figure 2. Spatial frequency (cpd) for 0.5 modulation transfer function (MTF) and 1.0 MTF. The difference in 0.5 MTF values was statistically significant (*P*=.004).

nea for a 5-mm pupil size were analyzed as parameters of optical quality.

Statistical Analysis

Analyses were performed using SPSS 11.0 for Windows (SPSS, Chicago, Ill). All values are presented as mean±standard deviation (SD). The comparison between microincision cataract surgery and small incision cataract surgery was established by the independent *t* test. A *P* value <.05 was considered statistically significant.

RESULTS

Microincision cataract surgery was performed on 30 eyes, and small incision cataract surgery was performed on 30 eyes. The baseline data for both groups including age, ΔSimK, and corneal power values are shown in Table 1. There was no statistically significant difference between the two groups for age, ΔSimK, and corneal power preoperatively.

The mean postoperative ΔSimK value was 0.78±0.38 D for group 1 and 1.29±0.68 D for group 2. The difference between the two groups was statistically significant (*P*=.001).

The mean postoperative total corneal high order aberration values were 2.04±1.23 μm for group 1 and 1.80±0.87 μm for group 2. The difference between groups was not significant (*P*=.408). Analyses of some individual Zernike terms such as total spherical aberrations, total coma aberrations, total trefoil, and total quadrafoil aberrations showed no significant difference between groups (Table 2; Fig 1).

Figure 2 plots the 0.5 MTF and 0.1 MTF values. For group 1, the mean 0.5 MTF value was 3.13±0.30 cycles per degree (cpd); for group 2 it was 2.75±0.63 cpd. The difference in 0.5 MTF values between groups was statistically significant (*P*=.004). For group 1, the mean 0.1 MTF value was 9.37±3.72 cpd; for group 2 it was 7.24±3.43 cpd. This difference in 0.1 MTF values was not statistically significant (*P*=.134).

DISCUSSION

Cataract surgery techniques and technology have been evolving over the past two decades, and efforts to reduce incision size have led to a new generation of microincision cataract surgery. Any incision on the cornea can potentially alter the optical power of the cornea; thus, it is assumed that smaller incisions will likely produce less surgically induced astigmatism. In this investigation of microincision cataract surgery and small incision cataract surgery, the smaller incision size associated with microincision cataract surgery resulted in significantly less postoperative corneal astigmatism. The results of this study confirm previous reports that used vectorial analysis to compare changes in astigmatism of eyes following microincision cataract surgery versus coaxial phacoemulsification.[5] Although traditional small incision cataract surgery is an excellent procedure, which induces low levels of astigmatism, microincision cataract surgery offers the potential for true astigmatically neutral incisions.

The optical quality of the cornea may be degraded not only because of low order aberrations such as astigmatism and defocus but also because of high order aberrations, which cannot be corrected effectively with spectacles.[7] The recent development of wavefront aberrometers for clinical use presents a tool to measure the various optical elements of the eye, separately and collectively. Previous studies have reported decreased optical performance in pseudophakic eyes, with increased astigmatism and high order aberrations such as coma and trefoil generated on the cornea.[3] In the present study, no statistically significant difference was noted between microincision cataract surgery and small incision cataract surgery with respect to generating total high order aberrations. Furthermore, there was no significant difference in individual higher order aberrations such as spherical aberration, coma, and trefoil. This study demonstrates that microincision cataract surgery has no significant advantage over traditional small incision cataract surgery with respect to minimizing the induction of corneal high order aberrations.

The corneal aberration data obtained by the OPD-Scan can be simulated as point spread function (PSF) and MTF values using the OPD-Station software. The PSF and MTF are metrics that indicate the retinal image quality from an incoming object. Data at 0.5 MTF represent the spatial frequency (cpd) at which the image contrast is degraded by 50% compared with the object contrast. Data at 0.1 MTF represent the spatial frequency in which the image contrast is degraded by 90% compared with the object contrast and correspond to the maximum resolution of the optical system.[6] Results of the current study show that microincision cataract surgery has a better MTF performance at 0.5 MTF than small incision cataract surgery, suggesting that microincision cataract surgery may improve the corneal optical quality to some degree over traditional surgery.

In conclusion, microincision cataract surgery minimized surgically induced astigmatism and showed a tendency toward improved optical quality of cornea compared with small incision cataract surgery. However, no difference was found in induction of total or high order aberrations between the techniques.

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