Ophthalmic Epidemiology, 12:293–297, 2005
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ISSN: 0928-6586
DOI: 10.1080/09286580591005778

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ORIGINAL ARTICLE

Comparison of Endothelial Cell Loss and Surgically Induced Astigmatism following Conventional Extracapsular Cataract Surgery, Manual Small-Incision Surgery and Phacoemulsification

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ABSTRACT *Purpose*: To compare the surgically induced astigmatism (SIA) and endothelial cell loss following conventional extracapsular cataract surgery (ECCE), manual small-incision cataract surgery (Blumenthal technique)(SICS) and phacoemulsification (PE) with non-foldable intraocular lens implantation. *Methods*: 186 cataractous eyes with nuclear sclerosis grade 3 or less were randomized to undergo ECCE, SICS or PE with intraocular lens (non-foldable) implantation after a detailed pre-operative assessment . Keratometry and specular microscopy were performed pre-operatively and 6 weeks postoperatively. Surgically induced astigmatism was calculated using the rectangular coordinate method (Holladay et al.). *Results*: Mean endothelial cell loss was similar for all three groups ($p = 0.855$); ECCE induced a loss of 4.72% (SD: 13.07); SICS 4.21% (SD: 10.29) and PE 5.41% (SD: 10.99). Mean SIA was 1.77D (1.61D) for the ECCE group, 1.17D (0.95D) for the SICS group and 0.77D (0.65D) for the PE group ($p = 0.001$). The magnitude of the difference between the SICS and the PE group was 0.4D. *Conclusion*: PE induced less astigmatism than SICS and ECCE in this study but the magnitude of the difference between SICS and PE was small. There was no significant difference in endothelial cell loss between the three groups.

KEYWORDS Cataract surgery; endothelial cell loss; extracapsular cataract extraction; small-incision cataract surgery; surgically induced astigmatism; phacoemulsification; intraocular lens implantation

Received 23 October 2004
Accepted 25 April 2005

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INTRODUCTION

Cataract is the leading cause of blindness worldwide.[1] The majority of these cases are in developing countries.[1] With advances in microsurgical techniques,

small-incision techniques have become increasingly popular. Phacoemulsification (PE) with a foldable lens is considered to be the Gold Standard of the cataract surgical techniques available today. However, the cost of the machine and the foldable lens preclude its use on a large scale in developing countries. Innovations in cataract surgical techniques have resulted in the development of manual small-incision techniques (SICS), which combine the sutureless advantages of phacoemulsification with minimum investment.[2] The Blumenthal technique is one such surgical approach.[3,4] The method involves the use of an anterior chamber maintainer and a typical scleral incision that resembles an angulated frown incision. The scleral pockets are dissected on either side of this incision to form a self-sealing funnel-shaped wound. An anterior chamber maintainer is used for hydroexpression of the intact nucleus through the scleral tunnel. The relatively large area of scleral dissection raises concerns about the amount of astigmatism induced by the method. While the anterior chamber maintainer helps in maintaining a formed anterior chamber throughout surgery, hydroexpression of the nucleus and the flow of fluid from the anterior chamber maintainer could be associated with significant endothelial cell loss. There is little data available on the endothelial cell loss and astigmatism induced by the technique of small-incision cataract surgery.[5] This study was designed to compare induced endothelial cell loss and astigmatism between three commonly used cataract surgical techniques in our practice.

METHODS

One hundred and eighty-six cases undergoing planned cataract extraction were randomized into three groups. Cases were recruited from the community ophthalmic care center of a tertiary care eye hospital. The community ophthalmic care center is a comprehensively equipped eye care hospital that caters to the indigent population. All patients are operated free of cost. The sample size was calculated with an 80% power and an alpha-error of 0.05% to detect a difference in astigmatism between cases of 0.5D using a standard deviation of 1.0D. This was calculated for a 20% drop-out rate. This sample size was adequate to detect a difference of 7% in endothelial cell loss between techniques.

All cases underwent a detailed pre-operative evaluation including vision, refraction, slit-lamp examination, applanation tonometry and dilated fundus examination. Keratometry (Appasamy Keratometer, Appasamy Associates, Chennai, India) was performed by an independent observer. Central endothelial cell counts were measured pre- and 6 weeks postoperatively using the Konan Noncon Robo Ca Sp 8000 (Konan Inc., Hyogo, Japan). Cell density was recorded as the number of cells per square millimeter. Details of the technique have been reported earlier.[6]

Those cases with cataractous lenses and an otherwise normal pre-operative examination were included. Lenses that had nuclear sclerosis grade III or less were included.[7] Persons with other potential causes of decreased vision were excluded. Non age-related or complicated cataracts were excluded, as were cataracts associated with glaucoma or retinal pathology. Cases with phacodonesis were also excluded.

The institutional review board approved the study. Cases were randomized into three groups based on computer-generated random numbers. Randomization was carried out at the time of admission and used the hospital numbers (which were allotted at the time of the first hospital visit) for allocation into different groups.

Surgery was done as an inpatient procedure with operated patients routinely admitted to the hospital for a day. All cases were operated by one of two experienced surgeons, each of whom had done at least 1000 cases of each technique. Cases were separately randomized for each surgeon so that equal numbers of each technique were performed by each surgeon. Peribulbar anesthesia with 2% lignocaine HCl and 0.5% bupivacaine HCl was routinely used. Surgery was performed using an operating microscope (Zeiss OPMI 1FR operating microscope, Carl Zeiss, Oberkochen, Germany).

Conventional extracapsular cataract extraction (ECCE) was performed in a standard manner with a 10–11 mm incision. A can-opener capsulotomy was routinely used and a 6.5-mm PMMA IOL (JF-111, John Fowler Ophthalmics Pvt Ltd., Mumbai, India) was placed in the bag or sulcus. The wound was sutured with 10-0 nylon. The choice of interrupted or continuous sutures was left to the individual surgeon.

Manual small-incision cataract surgery was performed by the Blumenthal technique.[3,4] A 5.0-mm scleral incision with 1.5-mm back-cuts was made 2 mm scleral from the limbus. The scleral tunnel and side pockets were dissected and an 8-mm internal opening was fashioned with a keratome. The anterior chamber maintainer (ACM) was introduced at 6o'clock and two side-ports at 10 and 2 o'clock were used routinely.

A can-opener capsulotomy or continuous curvilinear capsular rhexis (CCC) was performed in all cases. Viscoelastics (Viscomet, Unimed Technologies, Halol, India) were routinely used for capsulotomy and IOL insertion. The nucleus was hydrodissected and delivered into the anterior chamber. It was then hydroexpressed from the wound with or without the use of a Sheets glide. A 6.5-mm rigid PMMA lens (JF-111, John Fowler Ophthalmics Pvt Ltd., Mumbai, India) was inserted into the bag or sulcus. Sutures were not used routinely except in case of a wound leak.

Phacoemulsification (Storz Protege Microsurgical System, Storz Instrument Company, St. Louis, Missouri, USA) was performed through a 5.5-mm scleral incision. A CCC was done and the nucleus hydrodissected and hydrodelineated. The nucleus was then phacoemulsified using the divide & conquer or stop & chop technique. At the end of surgery the section was extended and a rigid 5.25-mm PMMA lens (JF-111, John Fowler Ophthalmics Pvt Ltd., Mumbai, India) inserted into the bag. Sutures were not routinely used.

No attempt was made at astigmatic modification of the section in any of the three techniques. All patients were routinely prescribed tapering doses of steroids postoperatively. Cases were reviewed on the first postoperative day, 1 week postoperatively and 6 weeks postoperatively. Additional visits were decided upon if necessary. At the 6th postoperative week, all cases underwent measurements of visual acuity and refraction, slit-lamp examination, keratometry, applanation tonometry, specular microscopy and dilated fundus examination. Independent observers performed refraction and keratometry in order to minimize bias.

Pre-operative examination data, intra-operative data regarding the surgical technique and postoperative data were all entered into a computerized database.

Age, surgically-induced endothelial cell loss and astigmatism were compared between the patients in the three groups using ANOVA. Absolute endothelial cell counts were used to calculate the percentage of change even if they showed an apparent increase. Statistically, over- and underestimates of the endothelial cell counts will be neutralized if actual counts are taken into account.[8] The gender distribution between the groups was compared using the Chi-square test.

Surgically-induced astigmatism was calculated from pre- and postoperative keratometric values as described by Holladay et al.[9] The suggested modification of the rectangular coordinate method was programmed into a computerized spreadsheet and used to calculate induced astigmatism. The actual cylindrical error prescribed for the patient (prescribed cylinder) after a subjective acceptance was compared for all three groups.

RESULTS

The 6-weeks follow-up was completed by 52/62 cases of ECCE, 53/62 cases of SICS and 60/62 cases of PE. There were no significant differences in age or sex between the subjects in the three groups who completed the final postoperative visit (Table 1).

There was no significant difference in endothelial cell loss for all three techniques ($p = 0.855$) (Table 2). ECCE induced a loss of 4.72% (SD: 13.07); SICS 4.21% (SD: 10.29) and PE 5.41% (SD: 10.99).

The amount of surgically-induced astigmatism differed significantly between the three groups ($p = 0.001$) (Table 3). Induced astigmatism was maximal (1.77D) for the ECCE group and minimal (0.77) for the PE group.

A similar result was seen when the mean of the magnitude of prescribed cylinders (ignoring the sign) was compared between the three groups (Table 3). When the groups were compared individually using Tukey's test there was a significant ($p < 0.05$) difference between ECCE and PE and ECCE and SICS, but no statistically significant difference between PE and SICS. Comparison of the actual cylinders prescribed shows a similar trend of higher prescribed cylinders with ECCE (Figure 1).

There were no major complications or posterior capsule rupture in any of the three groups. All cases were completed as planned with no case having to be converted. A posterior chamber intraocular lens was implanted in all eyes.

The proportion of cases with a best-corrected visual acuity of 6/12 or better is shown in Table 4. One case in the SICS group had macular pathology and one in the ECCE group had anterior ischemic optic neuropathy that accounted for the decrease in vision. On comparing

TABLE 1 **Demographics of the Subjects Included in Each Group**

	ECCE (n = 52)	SICS (n = 53)	PE (n = 60)	'p' value
Mean age (SD) yrs.	57.85 (8.01)	58.75 (8.68)	59.63 (7.64)	p = 0.49
Sex (M:F)	23:29	24:29	27:33	p = 0.73

TABLE 2 Mean (SD) Pre- and Postoperative Endothelial Cell Counts and Surgically-induced Endothelial Cell Loss

	ECCE (n = 52)	SICS (n = 53)	PE (n = 60)	'p' value
Pre-operative mean	2408.2 (372.1)	2460.1 (360.8)	2384.5 (324.7)	p = 0.50
Postoperative mean	2288.3 (435.2)	2345.5 (363.8)	2248.9 (371.3)	p = 0.41
Percentage reduction	4.72% (13.07)	4.21% (10.29)	5.41% (10.99)	p = 0.85

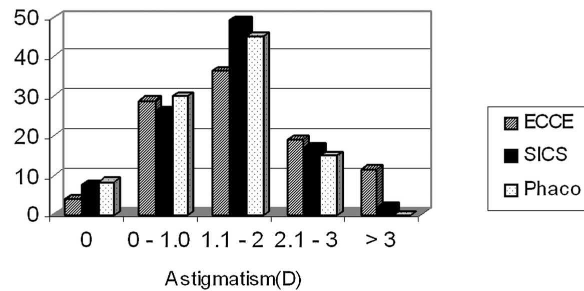

FIGURE 1 Distribution of prescribed cylinders among the three surgical groups.

the surgically attributable causes of decreased vision between the three groups, none of the cases that underwent PE or SICS had a best-corrected visual acuity less than 6/12, but 4/52 (7.69%) cases in the ECCE group had a best-corrected visual acuity ≤6/18 attributable to surgery. Of these, three cases were due to high cylindrical errors and one to posterior capsule opacification. Two of the three patients with high cylindrical errors had an improvement in best-corrected visual acuity to 6/9 and 6/6, respectively following suture removal, while one patient was lost to follow-up.

DISCUSSION

Manual small-incision techniques are gaining popularity as quick, relatively inexpensive techniques for large-scale cataract management in the developing world. One of the concerns has been the visual rehabilitation following surgery. In this series, SICS caused an intermediate amount of astigmatism as compared to ECCE and PE. In the ECCE group, 3/5 cases with visual acuity <6/12 were attributable to suture-induced astigmatism; no cases in either of the other groups had decreased vision due to astigmatism.

While SICS did induce a statistically greater amount of astigmatism than PE, the magnitude of the difference was only 0.4D. If one takes into account the instrumental cost and recurring costs associated with PE, this difference may be acceptable in most situations.

In this study, a 5.25-mm IOL was implanted after PE. Implantation of a foldable lens with PE in comparison to a non-foldable lens has been shown to produce less astigmatism.[10] However, we used a non-foldable lens as this reflects community-oriented cataract care in our country due to significant cost benefits.

ECCE + IOL was associated with significantly greater astigmatism and delayed visual rehabilitation, which was mostly suture-related. These cases had to come for an additional follow-up and required an additional procedure.

This study has its limitations. Since the study protocol did not permit intra-operative astigmatic correction by modification of wound construction or suturing, the actual estimates of astigmatism may be greater than what one would see clinically for SICS and PE, since eyes with larger pre-operative keratometric cylinders would be subjected to some form of astigmatic wound modulation.

TABLE 3 Mean Surgically-induced Astigmatism and Mean Prescribed Cylindrical Correction for Each Group

	ECCE (n = 52)	SICS (n = 53)	PE (n = 60)	'p' value
Mean induced astigmatism in diopters (SD)	1.77 (1.65)	1.1 (0.95)	0.77 (0.65)	p = 0.001
Mean of the magnitude of prescribed cylinder in diopters (SD)	1.9 (1.5)	1.5 (0.77)	1.38 (0.77)	p = 0.029*

*Tukey test p < 0.05 PE vs. ECCE

TABLE 4 Proportion of Cases with Postoperative Best-corrected Visual Acuity <6/18

	ECCE (n = 52)	SICS (n = 53)	PE (n = 60)
No. of cases with visual acuity of 6/18 or worse	5 (9.61%)	1 (1.8%)	0
Causes	High astigmatism: 3 Posterior capsule opacification: 1 Anterior ischemic optic neuropathy: 1	Macular scar: 1	0

One of the concerns about the Blumenthal technique is that the extent of dissection while creating the actual pockets may induce a large amount of astigmatism. This does not seem to be borne out in this study. The difference in astigmatism between PE and SICS is not large and suggests that manual SICS by the Blumenthal technique could be an effective technique for quicker visual rehabilitation than by conventional methods.

The endothelial cell loss induced by the three techniques is similar. Manual small-incision techniques have been thought to be associated with increased endothelial cell loss due to surgical maneuvers in the anterior chamber. The Blumenthal technique is different from other small-incision techniques that advocate fragmentation of the nucleus in the anterior chamber, as the nucleus is only partly prolapsed from the bag and then delivered through the section, minimizing the chances of endothelial damage. The use of the anterior chamber maintainer is a further advantage as it provides a deep anterior chamber throughout the operation.

Wright et al.[5] reported significant endothelial cell loss among persons with diabetes who underwent the Blumenthal technique. However, the modified Mininuc, which was used in that series, has since been modified[4] and does not require the entire nucleus to be prolapsed in the anterior chamber. Another significant difference between the two series is that no viscoelastics were used in the earlier report. The technique can be performed safely without the use of a viscoelastic. However, we used viscoelastics in this series, both for uniformity between the three groups and as it provides an additional safety margin during the procedure.

Only persons with early or moderate grades of cataract were included in this study. Harder nuclei and complicated cases were excluded, as they could be potential confounders for the surgical results. Both SICS and ECCE are simpler to perform in harder nuclei where the average surgeon may hesitate to perform PE.

Our results document the early surgically-induced astigmatism and endothelial cell loss for all three methods. A large proportion of India's cataract blind reside in rural India without uniform access to ophthalmic care. Techniques with no associated increase in postoperative morbidity that promote early visual rehabilitation with a reduced need for additional postoperative visits would improve patient compliance and improve cataract surgical results in the country.

Manual SICS and PE both cause less induced astigmatism then ECCE and are associated with earlier visual rehabilitation. While there was a statistically significant difference between PE and SICS, the magnitude of this difference was small. Endothelial cell loss was similar for all three techniques.

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