Effect of Extracapsular and Manual Small Incision Cataract Surgery with Intraocular Lens on Scanning Laser Polarimetry

Hemamalini Arvind, Ronnie George, Mani Baskaran, Prema Raju, Sathyamangalam Ve Ramesh, Lingam Vijaya
Glaucoma Project, Sankara Nethralaya, Medical and Vision Research Foundation, Chennai, India

Purpose: *To study the effect of cataract surgery with intraocular lens implantation on scanning laser polarimetry.*
Methods: *This was a prospective, cohort study. Scanning laser polarimetry using the GDx nerve fibre analyser was performed on 53 eyes of 53 patients who subsequently underwent cataract extraction and intraocular lens implantation by extracapsular extraction or manual small incision cataract surgery, and repeated at the final postoperative visit. Preoperative and postoperative values were compared using the paired* t *test. The patients were divided into 2 subgroups based on the type of surgery, and the mean differences between pre- and postoperative values for each parameter were compared between the subgroups using independent samples* t *test.*
Results: *There was a significant increase in scanning laser polarimetry values for superior and inferior maxima ($p < 0.001$ for both), superior and inferior ratios ($p < 0.001$ for both), superior/nasal ratio ($p < 0.001$), superior and inferior averages ($p < 0.001$ for both), ellipse average ($p < 0.001$), ellipse modulation ($p = 0.001$), maximum modulation ($p < 0.001$), and average thickness ($p = 0.002$) postoperatively compared with preoperative values. The number showed a significant decrease ($p < 0.001$). When eyes were classified into subgroups based on the type of surgery, there was no significant difference in the amount of change postoperatively for any of the parameters between the subgroups.*
Conclusions: *Scanning laser polarimetry parameters changed significantly following extracapsular or manual small incision cataract surgery with intraocular lens implantation. This change was not affected by the type of cataract surgery.*

Key words: *Cataract, Nerve fibers, Scanning laser polarimetry*

Asian J Ophthalmol. 2006;8:86-90

Introduction

GDx is a scanning laser polarimeter that measures the thickness of the peripapillary retinal nerve fibre layer (RNFL). GDx utilises a polarised 780 nm diode laser beam, which is focused on the retina and is reflected by the deeper retinal structures. As the beam double passes the RNFL, it undergoes a change in the state of polarisation, a phenomenon known as retardation. The degree of retardation is proportional to the thickness of the NFL through which the beam passes and is used to estimate the thickness of the NFL.[1] Scanning laser polarimetry (SLP) has been shown to be useful for distinguishing healthy eyes from glaucomatous eyes,[2] and to have good sensitivity and specificity for diagnosing glaucoma.[3]

Other ocular structures that may contribute to retardation are the cornea[4] and the crystalline lens.[5] The GDx version 1.0.16 (Laser Diagnostic Technologies, San Diego, USA) assumes a fixed slow axis of the corneal polarisation as 15° nasally downwards.[6] Inter-individual variations in corneal polarisation have been shown to exist.[6] A later version of the GDx incorporates a custom corneal compensator. However, corneal polarisation has been shown to be fairly constant in individual patients over time[7] and therefore would not affect longitudinal follow-up of individual patients.

Previous studies of the effect of cataract surgery with intraocular lens (IOL) implantation on SLP parameters have revealed higher SLP parameters after surgery, with some differences between individual reports.[8-11] However, all the studies performed to date have only investigated the effects of cataract removal by phaco-emulsification. In India, where the majority of patients do not have medical insurance schemes, many patients prefer the cheaper

Correspondence: Dr Lingam Vijaya, Sankara Nethralaya, Medical and Vision Research Foundation, 18, College Road, Chennai, India-600 006.
Tel: (91 44) 2827 1616/2823 3556; Fax: (91 44) 2825 4180;
E-mail: chennaigs@rediffmail.com

alternative of extracapsular cataract extraction (ECCE) or manual small incision cataract surgery (SICS) to phacoemulsification, which costs more. The effects of ECCE and manual SICS on the anterior segment birefringence may be different from that of phacoemulsification. ECCE and manual SICS require larger incisions, with more anterior incisions required for ECCE. The aim of this study was to examine the effects of ECCE and manual SICS with IOL implantation on SLP parameters.

Methods

This was a prospective, cohort study. The study was approved by the institutional review board and written informed consent was obtained from all participants.

Patients

Fifty three patients with visually significant cataract who satisfied all the inclusion criteria and were willing to enrol in the study were recruited from the outpatient clinic at the Medical and Vision Research Foundation, Sankara Nethralaya, Chennai, India, between June 2001 and November 2002.

Preoperative Evaluation

Preoperative evaluation included recording of best-corrected visual acuity (BCVA), slit-lamp examination, SLP (GDx, version 1.0.16; Laser Diagnostic Technologies, San Diego, USA), intraocular pressure (IOP) recording with applanation tonometry, gonioscopy, dilated fundus evaluation, grading of cataract according to the Lens Opacities Classification System II (LOCS II),[12] and optic disc stereo photography. The inclusion criteria were as follows:

- age 40 years or older
- IOP <22 mm Hg
- normal ocular examination except for the presence of cataract
- visual disability attributable to cataract
- willing to undergo cataract surgery.

SLP was performed by 1 of 2 experienced optometrists under normal ambient illumination with undilated pupils. One high-quality image of the optic disc and the peripapillary NFL was taken for each eye. Image capture was repeated up to a maximum of 3 times until a high-quality image that was well centred and focused, with equal illumination and adequate coverage in all quadrants, was obtained. The ellipse was placed around the optic disc and the symmetry analysis printout was obtained.

Cataract was considered significant if it was LOCS II grade ≥NII (nuclear opalescence of ≥grade II), and/or ≥PII (posterior subcapsular opacity of grade ≥II). However, surgery was advised only if the patient had significant visual disability attributable to the cataract. The eligible patients subsequently underwent cataract surgery with IOL implantation by 1 of 2 techniques, namely ECCE or manual SICS, by a modification of Blumenthal's method,[13] with all patients receiving a single-piece polymethyl methacrylate (PMMA) IOL (John Fowler Ophthalmics Ltd, Mumbai, India). The choice of the technique of cataract surgery was left to the surgeon.

Surgical Techniques

For ECCE, after administration of peribulbar anaesthesia, a 10- to 12-mm triplanar limbal incision was made straddling 12 o'clock. Can-opener capsulotomy was performed after viscoelastic injection. The section was then extended, and the nucleus was delivered by applying pressure at the 6 o'clock limbus and counterpressure just above the 12 o'clock limbus. Cortical clean up was done using a manual irrigation-aspiration cannula. The IOL was inserted under viscoelastic cover after cortical removal and dialled into position. The viscoelastic was then removed using the manual irrigation-aspiration cannula, and the wound was closed with 5 to 7 interrupted radial sutures.

For manual SICS,[13] a 5.5-mm partial thickness scleral incision with 1.5- to 2-mm backward extensions was made 2 mm posterior to the superior limbus. A scleral tunnel was dissected starting from this incision, and dissected toward the clear cornea so that the inner lip of the wound extended from the 10 o'clock to the 2 o'clock positions. An anterior chamber maintainer was introduced through an oblique corneal incision at 6 o'clock. A cystitome was introduced through a separate stab incision, followed by anterior capsulotomy and hydrodissection. The nucleus was manipulated into the anterior chamber and delivered by a combination of the stream of irrigation fluid from the anterior chamber maintainer, with the surgeon holding the lips of the wound open and manipulating the nucleus if required. Cortical clean-up was followed by IOL insertion under viscoelastic cover. Viscoelastic was then removed, and the wound tested for integrity.

Postoperative Evaluation

Postoperative SLP evaluation was done at least 6 weeks after surgery. In addition to SLP, all the procedures performed at baseline evaluation were repeated. Any patient with ≥3.5 D astigmatism was followed-up for review after 1 month for repeat refraction and keratometry. Suture removal was performed if necessary. SLP was performed when astigmatism was ≤3.5 D. Patients who reported for postoperative evaluation more than 6 months after the baseline examination were excluded.

Only those patients for whom high-quality GDx images were obtained before and after surgery were considered for analysis. In order that the analysis be clinically applicable, only those parameters that appear on the symmetry analysis printout were analysed.

Exclusion Criteria

Patients with poor-quality images, either pre- or postoperatively, corneal disease, media haze due to any cause other than cataract, IOP >21 mm Hg, glaucoma or glaucoma suspect, significant retinal pathology, optic nerve pathology, tilted discs, large areas of peripapillary atrophy, or an interval between pre- and postoperative SLP of more than 6 months were excluded.

Statistical Analysis

The differences between preoperative and postoperative GDx parameters were analysed for the whole group using paired *t* test. A p value of <0.0036 was considered significant after applying Bonferroni's correction for multiple comparisons. The mean differences between the ECCE and SICS groups for each of the parameters were compared using independent samples *t* test. When both eyes of the same patient satisfied the inclusion criteria, the right eye alone was included for analysis.

Results

Fifty three eyes of 53 patients satisfied all the inclusion criteria and were included for analysis; this was exclusive of 5 patients who had good images preoperatively, but poor images postoperatively. The mean age of the patients was 60.40 years (SD, 9.33 years). There were 24 men and 29 women. Thirty two eyes were right eyes and 21 were left eyes. The duration between pre- and postoperative SLP ranged from 44 to 174 days (mean, 86.81 ± 34.21 days). Seventeen eyes had a combination of nuclear, cortical, and posterior subcapsular cataract (PSC), 15 eyes had nuclear sclerosis and PSC, 6 eyes had nuclear and cortical cataract, 14 had only nuclear sclerosis, and 1 had PSC.

25 eyes underwent ECCE with IOL implantation and 28 eyes underwent manual SICS with IOL implantation. All the operations were uneventful. The postoperative spherical equivalent ranged from -2.75 to +0.88 (mean, -0.58 to +0.78). All patients had astigmatism ≤2.5 D at the time of the final postoperative evaluation. Table 1 shows the pre- and postoperative values for each of the 14 parameters. There was a significantly lower value noted postoperatively for the number, with higher superior maximum, inferior maximum, average thickness, superior average, inferior average, ellipse average, superior/nasal ratio, superior ratio, inferior ratio, maximum modulation, and ellipse modulation. The difference between postoperative and preoperative values for each of the 14 parameters, as well as spherical equivalent, were calculated separately for the 2 surgical groups and compared with each other (Table 2). There were no significant differences between the 2 surgical groups for any of the values.

Discussion

SLP has been shown to be an effective tool for screening for glaucoma. Since both cataract and glaucoma are diseases of ageing, the prevalence of both conditions increases with age. Patients undergoing longitudinal follow-up with the GDx are likely to require cataract surgery at some point. It is therefore important to know how the different cataract techniques influence GDx measures.

Several authors have examined the effect of cataract surgery by phacoemulsification and IOL implant on GDx parameters.[8-11] Park et al have reported a significant increase in NFL thickness after phacoemulsification with IOL, especially in eyes that received acrylic lenses.[8] Chiba et al also found positive correlations with cataract density and concluded that SLP may underestimate NFL thickness in individuals with dense cataract.[9] In an elaborate study of 138 eyes including in vivo and in vitro evaluation of different IOL types, Kremmer et al found higher NFL thickness values after cataract

Table 1. Comparison of preoperative and postoperative GDx parameters (n = 53).

Parameter	Preoperative Mean (SD)	Postoperative Mean (SD)	Postoperative-preoperative Mean	Percent change*	p Value
Superior maximum	82.380 (16.100)	88.420 (16.600)	6.040	7.33	<0.001
Inferior maximum	79.400 (16.640)	86.660 (16.700)	7.260	9.14	<0.001
Average thickness	59.250 (10.170)	61.700 (10.960)	2.450	4.14	0.002
Superior average	68.530 (12.760)	72.720 (12.100)	4.190	6.11	<0.001
Inferior average	72.080 (13.550)	77.910 (14.710)	5.830	8.09	<0.001
Ellipse average	62.720 (11.020)	66.340 (11.280)	3.620	5.77	<0.001
Superior integral	0.192 (0.040)	0.197 (0.040)	0.005	2.71	0.042
Superior/nasal	1.950 (0.330)	2.120 (0.340)	0.170	8.72	<0.001
Superior ratio	2.000 (0.390)	2.230 (0.420)	0.230	11.50	<0.001
Inferior ratio	1.940 (0.350)	2.180 (0.420)	0.250	12.89	<0.001
Symmetry	1.033 (0.100)	1.028 (0.130)	0.005	0.48	0.702
Maximum modulation	1.140 (0.330)	1.380 (0.420)	0.240	21.05	<0.001
Ellipse modulation	2.050 (0.560)	2.370 (0.680)	0.320	15.61	0.001
Number	30.600 (20.930)	19.420 (16.750)	-11.180	36.54	<0.001

* Refers to percentage change from preoperative value.

Table 2. Extracapsular cataract surgery (ECCE) versus manual small incision cataract surgery (SICS).

Parameter	ECCE (postoperative-preoperative) [n = 25] Mean (SD)	SICS (postoperative-preoperative) [n = 28] Mean (SD)	p Value
Superior maximum	5.920 (10.400)	6.140 (7.290)	0.92
Inferior maximum	8.680 (10.640)	6.000 (7.400)	0.28
Average thickness	2.800 (5.740)	2.140 (5.060)	0.66
Superior average	5.120 (6.880)	3.360 (5.520)	0.30
Inferior average	5.760 (8.650)	5.890 (7.970)	0.95
Ellipse average	4.440 (6.420)	2.890 (5.180)	0.33
Superior integral	0.006 (0.020)	0.004 (0.018)	0.73
Superior/nasal	0.130 (0.190)	0.190 (0.250)	0.32
Superior ratio	0.250 (0.430)	0.220 (0.310)	0.80
Inferior ratio	0.280 (0.430)	0.220 (0.300)	0.57
Symmetry	-0.012 (0.096)	0.002 (0.083)	0.57
Maximum modulation	0.230 (0.350)	0.250 (0.300)	0.83
Ellipse modulation	0.340 (0.600)	0.310 (0.700)	0.89
Number	-11.760 (18.880)	-10.680 (14.160)	0.81
Spherical equivalent	-0.725 (0.789)	-0.459 (0.767)	0.22

surgery for all IOL types, but this was statistically significant only for PMMA lenses.[10] These authors found that, in vitro, none of the IOLs had significant birefringence effects. Gazzard et al studied 49 patients with glaucoma before and after phacoemulsification with acrylic IOLs and found a significant increase in measures after surgery.[11] Another in vitro study of the birefringence properties of IOLs found that, except for compression-molded PMMA lenses, none of the other IOL designs — including lathe-cut PMMA (which was the design used in our study), acrylic, and silicone lenses — had significant birefringence properties.[14] The logical conclusion from these studies would be that the opacified crystalline lens has an effect on the SLP measurements, which is removed by its extraction by phacoemulsification. If this were true, and a cataractous lens gives an impression of a thinner NFL on GDx, cataract progression after glaucoma surgery may give an erroneous impression of worsening of GDx despite good IOP control. Differences in cataract surgery may alter the amount of anterior segment birefringence.

Effects on corneal curvature differ between the 3 types of cataract surgery due to the different sizes and placement of sections.[15,16] Other possible sources of variation are the placement of the IOL in ECCE, where decentration is common in view of the can-opener or envelope capsulotomy,[17] and a greater amount of remnant cortical fibres in ECCE and SICS compared with phacoemulsification despite good surgical technique.[15] This study addressed the effect of ECCE and SICS on GDx parameters and found results similar to previous results with phacoemulsification.

The best SLP parameter for the diagnosis of glaucoma has been shown to be the number.[18-21] This study showed a significant decrease in the number following surgery. According to the manufacturer, a number <30 is normal, 31 to 70 implies glaucoma suspect, and >70 implies glaucoma. The preoperative mean number was 30.60 and the postoperative mean number was 19.42. Considering that all the patients had a normal ocular examination except for cataract, the postoperative number appears to better represent the actual NFL status in this group than the preoperative number.

This study showed an increase in all absolute parameters following surgery, with all of them being statistically significant except the superior integral. The ratio-based parameters being ratios of one absolute parameter to another, any change in these parameters would depend on the change in the individual parameters, such as the numerator and/or the denominator. This study resulted in a significant increase in the superior/nasal ratio, superior ratio, and inferior ratio, implying that the superior and inferior maxima increased more than the nasal and temporal values in the respective ratios. The modulation parameters showed a significant increase, which could be explained on the same basis. There was no significant change in the symmetry, but this was as expected because both the superior and inferior maxima increased to a similar extent (Table 1) following surgery.

The type of surgery, whether ECCE or SICS, had no effect on the amount of postoperative change for any of the parameters. These findings correlate with the current understanding that the changes observed in GDx parameters are due to the removal of the cataractous lens. From the findings of this study, it appears that the differences in the anterior segment expected after ECCE and SICS do not cause birefringence effects qualitatively different from phacoemulsification as previously reported. All the patients in this study had astigmatism less than ±2.5 D at the time of SLP. Possibly, this may have minimised the effect of any corneal changes.

This study is the only study so far to examine the effects of ECCE and manual SICS on SLP parameters. The results would be relevant to any clinical scenario where ECCE or manual SICS are regularly performed, and specifically so if they are performed for patients being followed-up with the GDx.

This study used only 1 image per eye. However, it was ensured that this image was of high quality — it had to be well focused and centered, with adequate illumination and coverage in all quadrants. Image capture was repeated up to 3 times to obtain a high-quality image. If this was not possible, the patient was excluded from analysis. Colen et al have compared the mean of 3 images obtained by the NFA (GDx) to 1 image obtained as the best of 3 images and found no significant differences between them.[22] Better repeatability has been demonstrated with the NFA II but not with the GDx. A previous study by Kwon et al also used 1 good image per eye.[18] Although the maximum interval between pre- and postoperative SLP in the study reported here was 6 months, all patients had a normal ocular examination pre- and postoperatively. Patients with ocular hypertension, glaucoma, diabetic retinopathy, or any other optic nerve or retinal condition that may progress in 6 months were excluded. Therefore, a change in NFL status that may affect the results over 6 months was not expected. Even if there were a change, an increase in retardation values was observed rather than a decrease, which would be expected with time.

ECCE and manual SICS with IOL implant significantly alter SLP parameters. This change is not affected by the type of surgery. New baseline measurements are recommended following cataract surgery with IOL implantation.

Acknowledgement

The authors thank The Chennai Willingdon Corporate Foundation (Chennai, India) for their financial support, in part, to the study.

References

1. Weinreb RN, Dreher AW, Coleman A, et al. Histopathological validation of Fourier–Ellipsometry measurements of retinal nerve fiber layer thickness. Arch Ophthalmol. 1990;108:557-60.
2. Choplin NT, Lundy DC, Dreher AW. Differentiating patients with glaucoma from glaucoma suspects and normal subjects by nerve fiber layer assessment with scanning laser polarimetry. Ophthalmology. 1998;105:2068-76.
3. Tjon-Fo-Sang MJ, Lemij HG. The sensitivity and specificity of nerve fibre layer measurements in glaucoma as determined with scanning laser polarimetry. Am J Ophthalmol. 1997;123:62-9.
4. Van Blokland GJ, Verhelst SC. Corneal polarization in the living human eye explained with a biaxial model. J Opt Soc Am A. 1987;4:82-90.
5. Brink HB. Birefringence of the human crystalline lens in vivo. J Opt Soc Am A. 1991;8:1788-93.
6. Greenfield DS, Huang XR, Knighton RW. The effect of corneal polarization axis upon retinal nerve fiber layer thickness assessment using scanning laser polarimetry. Am J Ophthalmol. 2000;129: 715-22.
7. Greenfield DS, Knighton RW. Stability of corneal polarization axis measurements for scanning laser polarimetry. Ophthalmology. 2001; 108:1065-9.
8. Park RJ, Chen PP, Karyampudi P, et al. Effects of cataract extraction with intraocular lens placement on scanning laser polarimetry of the peripapillary nerve fiber layer. Am J Ophthalmol. 2001;132:507-11.
9. Chiba T, Kogure S, Tsukahara S. Influence of cataract on scanning laser polarimetry. Nippon Ganka Gakkai Zasshi. 2000;104:626-30. Japanese.
10. Kremmer S, Garway-Heath DF, De Cilla S, et al. Influence of cataract surgery with implantation of different intraocular lenses on scanning laser tomography and polarimetry. Am J Ophthalmol. 2003;136: 1016-21.
11. Gazzard G, Foster PJ, Devereux JG, et al. Effect of cataract extraction and intraocular lens implantation on nerve fibre layer thickness measurements by scanning laser polarimeter (GDx) in glaucoma patients. Eye. 2004;18:163-8.
12. Chylack LT, Leske MC, McCarthy D, et al. Lens Opacities Classification System II (LOCS II). Arch Ophthalmol. 1989;107:991-7.
13. Thomas R, Kuriakose T, George R. Towards achieving small-incision cataract surgery 99.8% of the time. Indian J Ophthalmol. 2000;48: 145-51.
14. Miura M, Osako M, Elsner AE, et al. Birefringence of intraocular lenses. J Cataract Refract Surg. 2004;30:1549-55.
15. Minassian DC, Rosen P, Dart JK, et al. Extracapsular cataract extraction compared with small incision surgery by phacoemulsification: a randomised trial. Br J Ophthalmol. 2001;85:822-9.
16. Zheng L, Merriam JC, Zaider M. Astigmatism and visual recovery after ‘large incision’ extracapsular cataract surgery and ‘small’ incisions for phakoemulsification. Trans Am Ophthalmol Soc. 1997;95:387-410; discussion 410-5.
17. Ram J, Apple DJ, Peng Q, et al. Update on fixation of rigid and foldable posterior chamber intraocular lenses. Part I: Elimination of fixation-induced decentration to achieve precise optical correction and visual rehabilitation. Ophthalmology. 1999;106:883-90.
18. Kwon YH, Hong S, Honkanen RA, et al. Correlation of automated visual field parameters and peripapillary nerve fiber layer thickness as measured by scanning laser polarimetry. J Glaucoma. 2000;9:281-8.
19. Horn FK, Jonas JB, Martus P, et al. Polarimetric measurement of retinal nerve fiber layer thickness in glaucoma diagnosis. J Glaucoma. 2000;8: 353-62.
20. Paczka JA, Friedman DS, Quigley HA, et al. Diagnostic capabilities of frequency doubling technology, scanning laser polarimetry, and nerve fiber layer photographs to distinguish glaucomatous damage. Am J Ophthalmol. 2001;131:188-97.
21. Lauande-Pimentel R, Carvalho RA, Oliveira HC, et al. Discrimination between normal and glaucomatous eyes with visual field and scanning laser polarimetry measurements. Br J Ophthalmol. 2001; 85:586-91.
22. Colen PT, Tjon-Fo-Sang MJH, Mulder PGH, et al. Reproducibility of measurements with the nerve fiber analyzer (NFA/GDx). J Glaucoma. 2000;9:363-70.