ORIGINAL ARTICLE

Accuracy of Intra Ocular Lens Power Calculation

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ABSTRACT

Objectives: To assess the accuracy of posterior chamber intraocular lens power calculation.
Study design: Prospective analytical study.
Place and duration of study: Department of Ophthalmology, Jinnah Hospital and Mayo Hospital Lahore. October 2002 to December 2002 and October 2006 to January 2007.
Subject and methods: A study of 100 cataractous eyes of patients attending the outpatients department and admitted in the ward. As the intraocular lens implanted is planned for emmetropia by using SRK II regression formula, mean deviation of the post-operative pseudophakic refractive error were noted. In case of cylindrical error, half of the error was taken as spherical equivalent. Range of error, mean error, and standard deviation were calculated
Results: The corrected postoperative visual acuity was 6/6 in 47 patients (47%), 6/9 in 39 patients (39 %), 6/12 in 13 patients (13 %) and 6/18 in 1 (1%) patient. Postoperative spherical equivalent was found to be 0 in 42 patients (42 %), ± 1D in 29 (29 %) patients, ± 2D in 20 (20 %) patients, ± 3D in 9 (9 %) patients.
Conclusion: The calculation of IOL power from biometric data offers valuable control over the postoperative refraction with the virtual elimination of significant unwanted postoperative refractive errors.

Key words: Cataract, axial length, keratometry, spherical equivalent

INTRODUCTION

Cataract or opacification of the human ocular lens is the commonest ageing change, which causes reversible reduction of vision. Modern cataract surgery offers near normal restoration of visual function. With the advent of intraocular lens (IOL) cataract surgery was revolutionized. Previously performed surgeries did effectively cure the blindness, however majority of the patients were left substantially hypermetropic, necessitating the use of high plus lenses to overcome the aphakic refractive error. Aphakic spectacles with their magnification, distortion and lack of ready vision place the patient in a disadvantageous position. Aphakic contact lens requires considerable manual dexterity and the ever present potential risk of secondary infection. The replacement of the opacified lens with an artificial intraocular lens is now a time tested treatment modality. The Intra ocular lens (IOL) offers the patient near normal vision. With the insertion of an IOL routinely during cataract surgery, a patient's postoperative refractive error may be minimal comparatively and hence reliance on spectacle and contact lenses may be significantly reduced[1].

To achieve ideal and optimum results, calculation of correct IOL power is necessary. The precision of such calculations depends mostly on the accuracy of axial length measurement as well as corneal curvature measurement.

The refractive power of the IOL to be implanted has to be accurately calculated. Calculation of intraocular lens power has become a refined science with the widespread use of highly accurate ultrasonographic equipment that measures the axial length of the eye and keratometry to measure the radius of curvature of cornea[2,3]. Current study caters to the IOL power calculation SRK-II formula, which is considered accurate in majority of the eyes when aiming for emmetropia.

MATERIAL AND METHODS

Study was a prospective analytical study conducted in the Department of Ophthalmology, Jinnah Hospital, and Department of Ophthalmology, Mayo Hospital, Lahore from October 2002 to December 2002 and October 2006 to 10 January 2007 respectively.

Non probability purposive sampling was done. All patients with cataract of ages between 40-65 years having normal fundi / retinal functions were included. Patients with controlled diabetes mellitus and hypertension were also included. Patients with retinal diseases like age related macular degeneration, uveitis, retinal detachment were excluded. Secondary intra ocular lens, posttraumatic, post-trabeculectomy eyes and with residual post operative posterior capsule thickening were excluded. All patients with pre-existing corneal opacity or corneal scarring, corneal dystrophy, keratoconus producing distortion (even by large pterygium) were excluded. 100 cataractous eyes of patients were studied who attend out patient department and those who were admitted in the eye ward for cataract surgery. Patient's personal profile including name, age and sex were recorded. In ophthalmological record, visual acuity both uncorrected and corrected were noted. Ocular adnexa was examined for dacryocystitis, blepharitis, lid abnormalities like ptosis, entropion, ectropion and tear film abnormalities were ruled out in order to prevent any ocular infection which may lead to the disastrous situation of endophthalmitis. Extra ocular movements were checked, and cover uncover test was done to rule out any squint. Slit lamp biomicroscopy was done to check the corneal status, with AC depth and activity. Pupil reaction to light and near, macular function tests were checked.Intraocular pressure was checked with the Goldmann applanation tonometry. The lens changes were categorized into dense cataract, posterior polar, nuclear sclerosis.A fully dilated fundus evaluation was done. Keratometry (K) was done by Keratometer (Canon, Japan). Axial length of the eyes were calculated by the ultrasonic A-Scan Biometer (Storz, USA) by anesthesiometry of the cornea with topical anesthetics. IOL Power was calculated by using the SRK-II Regression formula. The in-built computer was pre-programmed for "A constant" and anticipated anterior chamber (AC) depth of several models of IOLs used in the study. SRK-II was used for computations.

A written consent from the patient was taken regarding operation. The patients were briefed about the procedure. Both types of the procedures i.e extracapsular cataract extraction and phacoemulsification were performed accordingly. Patient were informed about the type of surgery to be done keeping in mind the availability of the type, model and power of the lens and of course the affordability was also considered. Posterior chamber lens was inserted using methyl cellulose as a cushion. Regular lenses Polymethyl methacrylate (PMMA) with 6.5mm diameter were used for ECCE and small diameter foldable lenses like Acrysof, Ceon, Medenium were used after Phacoemulsification. Postoperative unaided visual acuity was checked and recorded with the help of Snellen's chart at 2, 4, 6 and 8 weeks interval. In case of extra capsular cataract extraction (ECCE), sutures were removed after 10 weeks of surgery and then best corrected visual acuity was recorded after 1-2 weeks. Postoperative refraction was performed after removal of sutures in relevant cases. All the collected data on the performa was analyzed by using SPSS version 12.

The visual results are expressed as the percentage of eyes that achieved uncorrected visual acuity and best corrected visual acuity of 6/9 or better. The biometry prediction error (also known as deviation from intended refraction) was defined as the difference between the intended refraction of emmetropia i.e. 0.00 diopters and the spherical equivalent of the post-operative refraction. The variable under study is spherical equivalent of postoperative refractive error. Spherical equivalent is determined from adding sphere and half of the cylinder from the post operative refraction done at 8-10 weeks. The refractive results are given as spherical equivalent (SE) in diopters (D) and percentage of patients with biometry prediction errors of less than ±1, ±2 and ±3 variance of spherical equivalent in diopters, as this is the main variable of concern regarding the accuracy of intraocular lens implantation. Chi-square was used as the test of significance when studying the variance of spherical equivalent and p-value < 0.05 was considered as significant.

Frequency and percentage were computed for categorical variables like sex, pre-operative visual acuity, IOL power, corrected and uncorrected post operative visual acuity, post-operative spherical equivalent. Mean and standard deviation were computed for quantitative variables like age, keratometry, axial length.

RESULT

There were 100 patients in the sample, 44 (44%) were female and 56 (56 %) were male patients. (Table-1).The age range was between 40 -65 years with a mean age of 56.36 and standard deviation(SD) of ±7.42.The VA assessed preoperative was perception of light in 21 patients (21%), hand movement in 20 patients (20 %), counting finger in 33 patients (33 %), 6/60 – 6/36 in 21 patients (21%), 6/24 - 6/18 in 3 patients (3 %) and 6/12 in 2 patients (2%) (Table-2).The keratometry reading showed a range of 42.65 – 48.92 Diopter (D) with a mean of 47.16 D and SD of ± 1.05.The axial length as calculated by the

Storz A-scan was in the range of 19.99 mm to 25.90 mm with a mean of 22.97 mm and a SD of ± 1.00.The IOL power required, was calculated using the SRK-II regression formula. It was found to be between 15 -20 D in 65 patients (65 %) and 21-25 D in 35 patients (35%) with a mean of 19.63 D ± 2.32 of SD .The uncorrected post operative visual acuity was 6/6 in 6 patients (6%), 6/9 in 33 patients (33 %), 6/12 in 26 patients (26%), 6/18-6/24 in 31 patients (31%) and 6/36 -6/60 in 4 Patients (4%) (Table-3).

Table1: Distribution of cases by sex n = 100

Sex	Number	Percentage
Male	56	56.0
Female	44	44.0
Total	100	100.0

Table 2: Distribution of cases by pre-operative visual acuity n = 100

Visual acuity	Number	Percentage
Perception of light	21	21.0
Hand movement	20	20.0
Counting finger	33	33.0
6/60 - 6/36	21	21.0
6/24 – 6/18	3	3.0
6/12	2	2.0
Total	100	100.0

Table 3: Distribution of cases by uncorrected postoperative visual acuity n = 100

Visual acuity	Number	Percentage
6/6	6	6.0
6/9	33	33.0
6/12	26	26.0
6/18 – 6/24	31	31.0
6/36 - 6/60	4	4.0
Total	100	100.0

Table 4: Distribution of cases by corrected post-operative visual acuity n = 100

Visual acuity	Number	Percentage
6/6	47	47.0
6/9	39	39.0
6/12	13	13.0
6/18	1	1.0
Total	100	100.0

There were 74 patients who underwent extracapsular cataract extraction with IOL and 26 patients who had phacoemulsification with intraocular lens implantation. Sutures were removed in all patients with ECCE and PCL after ten weeks or so after surgery. Final refraction was done two to three months after surgery in case of ECCE and phacoemulsification with PCL. The corrected post operative visual acuity was 6/6 in 47 patients (47%), 6/9 in 39 patients (39%), 6/12 in 13 patients (13%) and 6/18 in 1 patient (1%) (Table-4). Post operative keratometry was measured and was found to be in the range of 43.44 – 48.98 diopters with a mean of 47.07 SD ± 1.22 .Post operative spherical equivalent was found to be 0 in 42 patients (42 %), ± 1D in 29 patients (29 %), ± 2D in 20 patients (20 %), ± 3D in 9 patients (9 %) (Table-5).

Table 5: Distribution of cases by variance of spherical equivalent n = 100

Spherical Equivalent (Diopter)	Number	Percentage
0	42	42.0
±1	29	29.0
±2	20	20.0
±3	9	9.0
Total	100	100.0

$P < 0.001$

The variance of outcome of spherical equivalent in both ECCE and phacoemulsifications, there was no significant difference between the resulting post operative spherical equivalent between the two types of the surgical techniques i.e extra capsular cataract extraction and phacoemulsification.

The chi-square test applied on the postoperative spherical equivalent which showed statistical significant results ($P< 0.001$).

DISCUSSION

The SRK[4-8] formula was chosen for the study as being the simplest of the various formulas available. Other formulae including the Binkhorst and Collenbrander are known to over correct short eyes to produce myopia which the SRK tends not to do[4-9]. All formulae have been found to be sometimes inaccurate for long eyes .In the SRK formula the A constant varies with individual surgical technique, implant style and manufacturer, but once it has been calculated the formula for De (power of implant for emmetropia) becomes extremely simple[10].There is an association between preoperative anterior chamber depth and the magnitude of spherical equivalent postoperatively[11].The majority of the iris diaphragm movement occurs during the first week post cataract surgery[11], therefore, hypothetically, perhaps a pre operative deep AC results in a more posteriorly positioned iris diaphragm after the first post operative month and may limit the anteroposterior movement of the intraocular lens[12].In contrast, a shallow AC preoperatively may be associated with relatively more anteriorly positioned iris diaphragm postoperatively, allowing more freedom of movement for the implanted IOL. This may account for the increased odds that the magnitude of refractive shift would be at least 0.25D as anterior chamber depth decreased.[11,12]

It is said that the degree of cylindrical refractive shift in the horizontal meridian is associated with the type of incision during the surgery. Scleral wounds demonstrated more against-the-rule shift. In previous studies, it was suggested, that there was no refractive shift for scleral wounds than for corneal wounds.[11-16] The difference in horizontal cylinder change would have only accounted for a spherical equivalent refractive shift of approximately - 0.15D in the myopic direction and therefore would have had little impact clinically.[1]

Surgical technique will influence corneal curvature by producing flattening and by inducing surgical astigmatism. Corneal flattening will reduce the axial length, tending to produce hypermetropic results in contrast to the myopic bias of the several errors of axial length measurement. Induced astigmatism reduces the value of attempts to control refraction and should be minimized by the accurate suture placement and correct suture tension in cases of extracapsular cataract extraction.

In our study, postoperative refraction was done after two weeks of suture removal in cases of ECCE in order to avoid only modifiable factor that could effect the postoperative astigmatism. Clinical results are presented as spherical equivalent power and as true spherical component of refraction after adding half of the cylinder to the sphere. Refraction was done with the help of Canon Autorefractometer. This was done because of the machine's satisfactory accuracy and reliability[17] and to ensure objective measurement of the study's outcome factor to eliminate the bias as the examiner was not masked to each patient's exposure factor. The repeatability of the autorefractor has been reported to have a SD of > 0.25D.A refractive shift of 0.5D or greater only be considered clinically significant when comparing autorefractors and subjective refraction.[15,16]

In different studies post operative spherical equivalent within ±1 D was reported as 72.9% by Drexler[18], 86.7% by Haigis[19], 79% by Rose[20] while it was seen in 71% of my patients which is comparable. Regarding postoperative spherical equivalent within ±2 D seen in 96.4% by Drexler[18], 99% by Haigis[19], 98% by Rose[20] and 91% in my study which is again is very comparable.SRK methods works at its best for the refractive range for which it was derived. Because of the indentation inherent in contact method myopic shift in post operative refractive error is expected whereas in Partial coherence laser interferometry (PCLI), it measures upto retinal pigment epithelium, the 100um retina thickness differ as fixation is at internal limiting membrane level a hypermetropic shift is seen. Since partial coherence laser interferometry relies on adequate foveal fixation, eyes with corneal scarring, dense cataract, posterior capsule plaques, macular degeneration, and eccentric fixation fail to obtain reliable results. The PCLI technique has a failure rate reported upto 15%[21,22], although it is modern and more accurate but it has its limitations in our patient population.

In our study, 74% of the patients had dense cataract, therefore applanation ultrasonography, still has a very dominant place in IOL power calculation in our setup. The brain requires similar sized images from both eyes if they are to be fused to give binocular single vision. The visual system exhibits a high degree of plasticity and tolerance of aniseikonia allowing for imperfections in the natural optical system. The final image size perceived at the visual cortex will be the end result of modification of the images falling on the retinae. Retinal photoreceptor density may differ between the eyes and there may be cortical modifications of the visual signals. For fusion to occur the retinal images must lie within panums area, and in aniseikonia this may be achieved for central vision with increasing disparity towards the periphery. By calculating the IOL power from biometric data of corneal power and axial length it is possible to reduce postoperative anisometropia to within about 2 diopters in almost all cases.[23]

All empirical formulas are strictly true only for the population and the methods for which they were derived. When they are applied to other data, offset errors may show up, reflecting systematic differences between the reference population. With SRK formula for IOL calculation this problem has been solved by substituting the offset error with a variable A constant, the value of which varies primarily according to the IOL style but also according to surgical technique and measuring technique[4-7].

We used the applanation technique to measure the axial length as originally used by Sanders and colleagues[4] to eliminate the offset errors. When the other errors in the measurement of axial length are considered such as alignment errors, calibration errors and differences in measuring techniques, a prior correction of axial length because of the retinal thickness may seem to be of academic interest only. Our results show that preoperative biometry is a practicable routine procedure and has proved very useful, and it compares well with those in other published series.

CONCLUSIONS

The calculation of IOL power from biometric data offers valuable control over the postoperative refraction with the virtual elimination of significant unwanted postoperative refractive errors.

Eyes with any given refraction may achieve that state by a number of possible combinations of the several optical components, which must be taken into consideration in IOL power selection.

A new technique for the use of ocular biometry is in clinical practice, which is an alternative to the ultrasound, the conventional method of measuring axial length, is IOL Master. Its accuracy, precision and repeatability is the focus of recent studies.

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