ISRA MEDICAL JOURNAL | Volume 7 - Issue 3 | Jul - Sep 2015

KERATOMETRY, AXIAL LENGTH AND INTRA-OCULAR LENS POWER VARIATIONS OBSERVED DURING BIOMETRY

MUSTAFA ABDUL HAMEED ISMAIL[1], SABEEN CHAUDHRY[1],

ABSTRACT

OBJECTIVES: To document the variations in keratometry, axial length of eye and intra-ocular lens (IOL) power observed during biometry of cataract patients and to find any significant gender difference.

STUDY DESIGN: A retrospective review of the biometry records.

PLACE AND DURATION: Saeed Eye and Medical Complex, Rawalpindi from 1st Nov 2010 to 31st Dec 2014.

METHODOLOGY: Patients of senile cataract were included from the biometry records. Keratometry readings of vertical and horizontal corneal meridian (K1 & K2) were measured with automated keratometre and axial length was measured with contact A-scan. Power of IOL was calculated by using SRK-T formula in patients with axial lengths between 22 and 26, Hoffer Q for axial lengths <22mm and Haigis for axial lengths >26 mm with A-constant of 118. The data was analyzed with SPSS version 16.

RESULTS: 908 patient records were analyzed. The mean ±SD keratometry readings (K1 and K2) were 43.46 ±1.68 D and 44.41±1.98 D respectively. The mean ±SD axial length was 23.45±1.20mm. SRK-T was used in 818 (90.1%) cases, Hoffer Q in 68 (7.5%) and Haigis in 22 (2.4%) of cases. The mean ±SD intra-ocular lens power was 20.22±3.06D. Gender based comparison showed that the mean ±SD K1 in males (42.95 ±1.54D) was less than 43.88 ±1.67D for females (p=0.0001). The mean ±SD K2 for males (43.9 ±1.66D) was also less in females (44.78 ±1.70D) (p=0.0001). The mean ±SD axial length of eyes in males was 23.81 ±1.23mm significantly more than 23.16 ±1.08mm in females (p=0.0001). The mean ±SD IOL power was 19.68 ±3.19D in males and 20.67 ±2.86D in females (p=0.0001).

CONCLUSION: The mean keratometry readings (K1 and K2) were 43.46 ±1.68 D and 44.41±1.98 D respectively. The mean axial length was 23.45±1.20mm and mean intra-ocular lens power was 20.22±3.06D. Gender based analysis showed that females have more keratometric readings but shorter axial lengths than males and required more power of IOL to be implanted after cataract surgery.

KEY WORDS: Keratometry Readings, Axial Length, Biometry, Intraocular Lens.

INTRODUCTION

Biometry is the process of measuring the power of the cornea and the axial length of the eye, and using this data to determine the ideal intraocular lens power[1]. If this calculation is not performed accurately, the patients may be left with a significant refractive error post-operatively. The power of the cornea, the power of the lens, and the length of the eye are the three factors on which the refractive power of human eye depends. When cataract is removed, the cataractous lens is replaced by an artificial lens implant. By measuring both the length of the eye in mm and the power of the cornea in Diopters (Keratometry), we can calculate the power of the intraocular lens (IOL) needed, by using various intra-ocular lens calculating formulas.

A-scan is an amplitude modulation ultrasound scan. It provides data on the axial length of the eye. Commonly, A-scan is done using an applanation probe in contact with the cornea, but the immersion method may also be used[2]. Immersion method avoids any corneal compression that can give a falsely short axial length and gives high quality, consistent results.

Keratometry is the measurement of the corneal radius of curvature. Keratometry attempts to predict the total corneal power based on the measurement of the anterior corneal surface[3]. The measurements are normally recorded along two orthogonal meridians, giving the maximum and minimum corneal powers. These are known as K-values or corneal Ks. The difference between the K-values is the corneal astigmatism. Keratometry can be acquired with a variety of instruments either manually or via automated keratometres. Keratometry is a critical measurement in intra-ocular lens power calculation because errors in measurements are matched 1:1 to refractive outcomes[4]. If keratometry is inaccurate, there can be an unexpected refractive surprise post-operatively.

There are several different biometry formulas that can be used depending on the actual characteristics of the eye. The Hoffer Q, Holladay I, and SRK/T formulae are all commonly used. The older SRK I and II regression formulae are now regarded as obsolete[6]. More recent formulae, such as the Holladay II or Haigis can increase accuracy in special situations.

The purpose of this study was to document the variations in keratometry, axial length of eye and intra-ocular lens powers observed during biometry of our patients, find any significant gender difference and to compare it to the national and international data available in literature.

1. Assistant Professor of Ophthalmology
Yusra Medical and Dental College, Islamabad.

Corresponding to:
Mustafa Abdul Hameed Ismail
Assistant Professor of Ophthalmology
Yusra Medical and Dental College, Islamabad
E mail: drmahieye@yahoo.co.uk

METHODOLOGY

A retrospective review of the biometry record of the patients undergoing cataract surgery (phacoemulsification) with IOL implantation in our clinic, Saeed Eye and Medical Complex, Rawalpindi, from 1st Nov 2010 to 31st Dec 2014 was done. All patients were registered and a specially designed biometry form was filled for their IOL power calculation at the time of their surgery. For the purpose of study only patients of senile cataract were included. Patients with other causes of cataract were excluded from the study. Keratometry readings as diopteric power (D) of vertical and horizontal corneal meridian (K1 & K2) of every case were measured with automated keratometre (Huvitz RK). Axial length of eyeball in mm was measured with contact A-scan (Micro Medical Devices, USA) in all cases. Power of IOL was calculated by using SRK-T formula in patients with axial lengths between 22 and 26. For axial lengths shorter than 22mm Hoffer Q was used and for axial lengths more than 26 mm Haigis was used. A-constant of 118.0 was used in all calculations.

The data was fed to SPSS version 16 for analysis. Three kinds of data analysis were performed. First, the whole data was analyzed for gender, laterality of eye, keratmetric values (K1 and K2), axial length, formula used and IOL power. Second, the keratometry readings (K1 and K2) and the axial lengths was further sub-divided into groups and the numbers of cases with percentages were calculated for each variable in each group. The keratometry readings were divided in 11 sub groups, the first group being <40 D and the last one >49D. The rest of the groups were the in between readings divided in 1D interval (40-40.99, 41-41.99, 42-42.99, 43-43.99, 44-44.99, 45-45.99, 46-46.99, 47-47.99 and 48-48.99). The axial lengths were divided in 8 sub groups. The first and the last group was <21mm and >27mm group. The rest of the readings were divided in 1mm intervals (21-21.99, 22-22.99, 23-23.99, 24-24.99, 25-25.99, and 26-26.99). Third, the student t-test was applied to compare means of axial length, keratmetric values and IOL power among the male and female gender groups.

RESULTS

A total of 908 patient records were included in the study. Amongst them 412 (45.4%) were males and 496 (54.6%) were females. Right eye was examined in 457 (50.3%) cases while left eye was examined in 451 (49.7%) of cases. In 908 cases, the mean ±SD keratometry readings (K1 and K2) were 43.46 ±1.68 D and 44.41±1.98 D respectively. The mean ±SD axial length was 23.45±1.20mm in these cases. SRK-T formula was used in 818 (90.1%) cases whereas Hoffer Q and Haigis was used in 68 (7.5%) and 22 (2.4%) of cases respectively. The mean ±SD intra-ocular lens power came out to be 20.22±3.06D using A-constant of 118.

As a second step, the keratometric readings and the axial length of eye was divided in subgroups for further analysis. The number of cases and percentages of K1, K2 and axial length of eyes sub-divided in groups are shown in Tables 1 & 2. For K1, most of the cases were in the 42-44.99D sub groups (sub group 4, 5 and 6), being 162 (17.8%) between 42-42.99, 203 (22.4%) between 43-43.99D and 187 (20.6%) between 44-44.99D, having a cumulative number of 552 (60.79%, n=908). For K2, most of the cases were in the sub-groups of 43-45.99D (sub groups 5, 6 and 7). These were 172 (18.9%) cases from 43-43.99D, 205 (22.6%) from 44-44.99D and 180 (19.8%) cases with total of 557 (61.34%, n=908). The axial length of the eye ball showed most of the cases in axial length sub-groups of 22-24.99mm (sub-group 3, 4 and 5) with 256 (28.2%) cases in 22-22.99mm, 365 (40.2%) in 23-23.99mm and 175 (19.3%) in 24-24.99mm subgroup. They make up a total of 796 (87.66%) of total 908 cases studied. (Graph 1, 2, 3)

The results were further analyzed, for any significant variations in males and females. The mean ±SD K1 in males was 42.95 ±1.54D and was 43.88 ±1.67D for females (p=0.0001). The mean ±SD K2 for males was 43.9 ±1.66D and in females it was 44.78 ±1.70D. (p=0.0001). The mean ±SD axial length of eyes was 23.81 ±1.23mm and 23.16 ±1.08mm in males and females respectively. The mean ±SD IOL power needed to achieve emmetropia was 19.68 ±3.19D in males and 20.67 ±2.86D in females (p=0.0001)(Table 3) The IOL power was calculated by using SRK-T in 381(92%) males whereas it was used in 437 (88%) females. Hoffer Q was used in 17 (4.1%) males and 51 (10.3%) females. Haigis was used as IOL calculating formula in 14 (3.4%) males and in 8 (1.6%) females.

TABLE – I: K 1 & K2 SUB GROUPS WITH NUMBER OF CASES IN EACH GROUP AND THEIR % AGES (n=908)

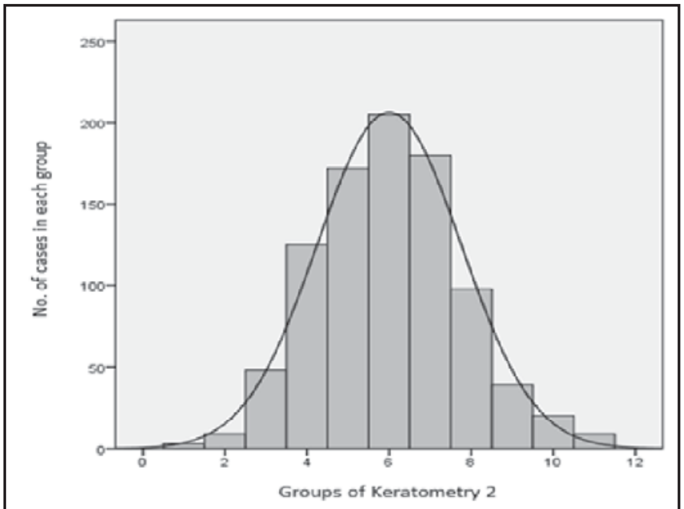
Sub-Group Number	Keratometry in Diopters	K1 (n with %age)	K2 (n with %age)
1	<40	10 (1.1%)	3 (0.3%)
2	40-40.99	49 (5.4%)	9 (1.0%)
3	41-41.99	112 (12.3%)	48 (5.3%)
4	42-42.99	162 (17.8%)	125 (13.8%)
5	43-43.99	203 (22.4%)	172 (18.9%)
6	44-44.99	187 (20.6%)	205 (22.6%)
7	45-45.99	117 (12.9%)	180 (19.8%)
8	46-46.99	45 (5%)	98 (10.8%)
9	47-47.99	21 (2.3%)	39 (4.3%)
10	48-48.99	2 (0.2%)	20 (2.2%)
11	>49	0	9 (1.0%)

TABLE - II: AXIAL LENGTH SUB-GROUPS WITH NUMBER OF CASES IN EACH GROUP WITH %AGES (n=908)

Sub-Group Number	Axial Length (mm)	Cases with %age
1	<21mm	5 (0.6%)
2	21-21.99mm	48 (5.3%)
3	22-22.99mm	256 (28.2%)
4	23-23.99mm	365 (40.2%)
5	24-24.99mm	175 (19.3%)
6	25-25.99mm	38 (4.2%)
7	26-26.99mm	10 (1.1%)
8	>27mm	11 (1.2%)

TABLE - III: GENDER BASED COMPARATIVE ANALYSIS OF KERATOMETRY (K1 & K2), AXIAL LENGTH AND IOL POWER

	Males (n=412)	Females (n=496)	P values
Keratometry, K1(Diopters)	42.95±1.54D	43.88±1.67D	0.0001
Keratometry, K2 (Diopters)	43.90±1.66D	44.78±1.70D	0.0001
Axial length of eye (mm)	23.81±1.23mm	23.16±1.08mm	0.0001
IOL power (Diopters)	19.68±3.19D	20.67±2.86D	0.0001

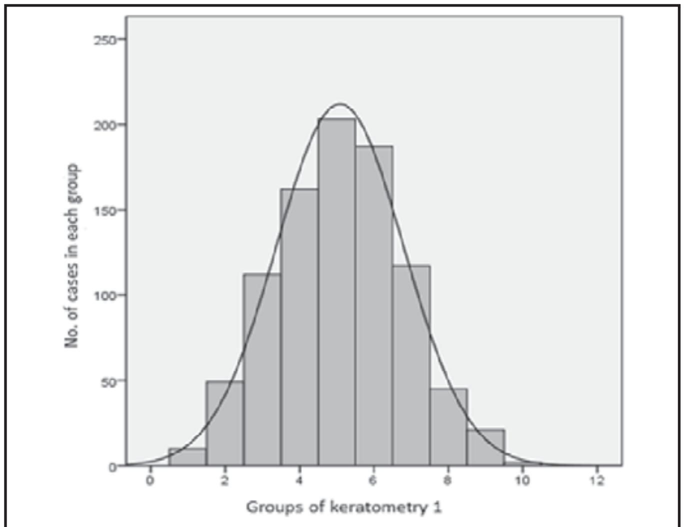


GRAPH 2: DISTRIBUTION CURVE OF CASES IN EACH SUB-GROUP OF KERATOMETRY 2

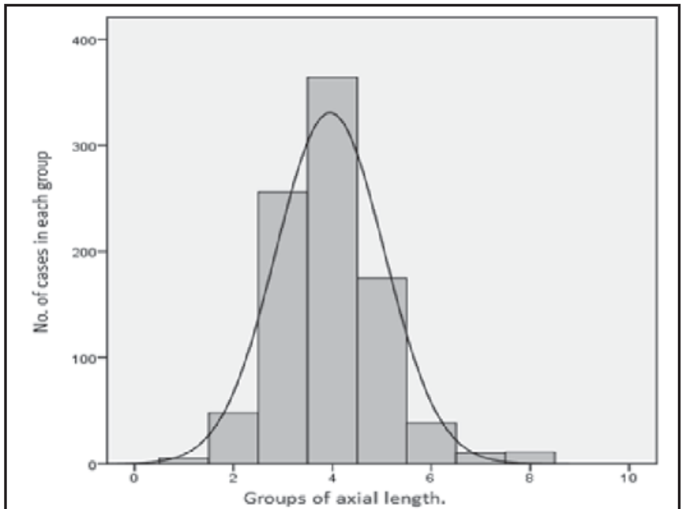
DISCUSSION

Senile cataract, opacification of crystalline lens with increasing age, causes reversible blindness in elderly population. According to WHO, cataract is the leading cause of blindness globally and about 90% of blind people live in poor countries[6]. According to Pakistan National blindness and visual impairment survey 2007[7], cataract is the leading cause of blindness in Pakistan as well, accounting for 51.5% blindness[8]. However, in 1999, a survey concluded that it was contributing 66.7% to total blindness. Phacoemulsification with intra-ocular foldable lens implantation is the standard surgery for cataract patients[9]. In most of the cases, the aim of surgery is to achieve emmetropia for patients and biometry has become an essential tool for IOL power calculation. Use of different formulas in different situations help the operating surgeon achieve the required post-operative visual outcome and avoids refractive surprises.

In our study of 908 cases, the mean ±SD keratometry readings (K1 and K2) were 43.46 ±1.68 D and 44.41±1.98 D respectively. A recent local study from Hyderabad reported these keratometric values as K1: 44.00 ± 1.83 D and K2: 44.78 ± 1.88 D, slightly higher than our means[10]. A study from Swat reported the mean K1 as 42.48± 2.17D and the mean K2 as 42.65 ± 2.10 D, lower than our means[11]. Internationally, a series of 450 cases had mean keratometry reading of 43.83 ± 1.56 D[12], while in another study the mean keratometry reading was 43.29 ± 1.57 D[13].



GRAPH 1: DISTRIBUTION CURVE OF CASES IN EACH SUB-GROUP OF KERATOMETRY 1



GRAPH 3: DISTRIBUTION CURVE OF CASES IN EACH SUB-GROUP OF AXIAL LENGTHS

Gender based comparison of the corneal curvature readings in our study found a significantly higher K1 and K2 in females than males. The mean ±SD K1 in males (42.95 ±1.54D) was significantly lower than females (43.88 ±1.67D). The mean ±SD K2 for males (43.9 ±1.66D) was significantly lower than in females (44.78 ±1.70D). Similar difference was reported earlier where gender based comparison of keratometric values showed that the means values were 43.68 ± 1.80D for males and 44.31 ± 1.80D for females.10 Similar gender difference came out in a Canadian study when the mean keratometry readings were higher in females compared to males. (Males: 43.54 ± 1.47D, Females: 44.21 ± 1.40)[14]

The mean ±SD axial length was 23.45±1.20mm in our cases. The mean axial length of the eyes of patients undergoing cataract surgery was 22.96 ± 1.04mm and 22.52 ± 1.13 mm in similar local studies[10, 11]. A comparative study done among different ethnic populations showed the axial length of Asians (East Asian 23.89 mm, South Asian 23.60 mm) was longer than Caucasians (23.24 mm) and Middle Eastern (23.45mm)[15] population. The mean axial length was considerably larger in our study group compared to rural Central Indian population (22.6±0.91 mm)[16] and South Indian population (22.8±0.8 mm)[17]. In adult population of Beijing, the mean ocular axial length was found to be 23.3±1.1 mm. In multivariate analysis they found that axial length was significantly associated with the higher body height, higher level of education and urban region of habitation[18]. This may explain the difference between our study and previous public hospital based studies. Gender based analysis of axial lengths revealed significantly shorter female eyes (23.16 ±1.08mm) than males (23.81± 1.23mm). This gender difference was also highlighted in local study in which it was noticed that females had a shorter mean axial length as compared to males (Females : 22.81±1.05 mm, Males: 23.13± 1.00mm). The Los Angeles Latino Eye Study revealed an association between axial length and gender, and like our study, women had shorter eyes than men[19]. In the Beaver Dam Eye Study, also, the mean axial length was greater in men than in women[20].

The study also showed that mean ±SD IOL power needed to achieve emmetropia in males (19.68 ±3.19D) was less than females (20.67 ±2.86D). Hoffer Q, formula used for shorter than 22mm eyes, was used in lesser males (4.1%) than females (10.3%). Haigis, formula used for more than 26mm eyes was used as IOL calculating formula in more males (3.4%) than females (1.6%). These findings are also comparable to other national and international studies showing that females are more hypermetropic and need lower IOL power after cataract surgery than males[21].

CONCLUSIONS

The mean keratometry readings (K1 and K2) of all the cases were 43.46 ±1.68 D and 44.41±1.98 D, mean axial length was 23.45±1.20mm. The mean intra-ocular lens power was 20.22±3.06D. There is statistically significant difference in the keratometric and axial length readings of males and females. Females tend to have more keratometric readings but shorter axial lengths than males. The females require more power of IOL to be implanted after cataract surgery.

REFERENCES

1. Dictionary of Optometry and Visual Science, 7th edition. Butterworth-Heinemann; 2009.p 156.
2. Astbury N, Ramamurhty B. How to avoid mistakes in biometry. Community Eye Health 2006; 19(60): 70–71.
3. J. Schwiegerling. Keratometry . In: Field Guide to Visual and Ophthalmic Optics, SPIE Press: Bellingham, WA; 2004.p 86-89.
4. Gutmark R, Guyton DL. Origins of the Keratometer and its Evolving Role in Ophthalmology. Survey of Ophthalmology 2010; 55(5): 481-97.
5. Gale RP, Saha N, Johnston RL. National Biometry Audit II. Eye 2006; 20: 25–28.
6. World Health Organization. VISION 2020 Global initiative for the elimination of avoidable blindness: Action plan 2006-2011. Avoidable visual impairment- A human, social and developmental issue. Geneva, 11-13 July 2006. p 1.
7. Dineen B, Bourne RRA, Jadoon Z, Shah SP, Khan MA, Foster A, et al. Causes of blindness and visual impairment in Pakistan. The Pakistan national blindness and visual impairment survey. Br J Ophthalmol. 2007; 91(8): 1005–10.
8. Pakistan national plan for prevention of blindness, 2nd five year plan (1999–2003). Islamabad, Ministry of Health, 1999; p 5.
9. Minassian DC, Rosen P, Dart JKG, Reidy A, Desai P, Sidhu M. Extra-capsular cataract extraction compared with small incision surgery by phacoemulsification: a randomized trial. Br J Ophthalmol 2001; 85: 822-29.
10. Nizamani NB, Surhio SA, Memon S, Talpur KI. Axial Length Variability in Cataract Surgery. J Coll Physicians Surg Pak 2014; 24(12): 918-21.
11. Rashid H, Naseem A, Rahman F. Two years review of Intraocular Lens power calculation in Ophthalmology Department of Saidu Teaching Hospital, Swat. Pak J Ophthalmol 2007; 23(3): 122-25.
12. Hoffer KJ. The Hoffer Q formula: a comparison of theoretical and regression formulas. J Cataract Refract Surg 1993; 19: 700-12.
13. Elder MJ. Predicting the refractive outcome after cataract surgery: the comparison of different IOLs and SRK-II v SRK-T. Br J Ophthalmol. 2002; 86: 620-22.
14. Al-Mahmoud T, Priest D, Munger R, Jackson WB. Correlation between refractive error, corneal power and thickness in a large population with a wide range of ametropia. Invest Ophthalmol Vis Sci 2011; 52 (3):1235-42.
15. Tariq YM, Samarawickrama C, Pai A, Burlutsky G, Mitchell P. Impact of ethnicity on the correlation of retinal parameters with axial length. Invest Ophthalmol Vis Sci 2010; 51(10):4977-82.
16. Nangia V, Jonas JB, Sinha A, Matin A, Kalkarni M, Panda-Jonas S. Ocular axial length and its associations in an adult population of central rural India: the Central India Eye and Medical Study. Ophthalmology 2010; 117 (7): 1360-66.
17. George R, Paul PG, Baskaran M, Ramesh SV, Raju P. Ocular biometry in occludable angles and angle closure glaucoma: a population based survey. Br J Ophthalmol 2003;87: 399–402.
18. Yin G, Wang YX, Zheng ZY, Yang H, Xu L, Beijing eye study group. Ocular Axial Length and Its Associations in Chinese: The Beijing Eye Study. PLoS ONE 2012; 7 (8):e43172.
19. Shufelt C, Fraser-Bell S, Ying-Lai M, Torres M, Varma R. Refractive error, ocular biometry, and lens opalescence in an adult population: the Los Angeles Latino Eye Study. Invest Ophthalmol Vis Sci 2005; 46: 4450–60.
20. Lee KE, Klein BE, Klein R, Quandt Z, Wong TY. Association of age, stature, and education with ocular dimensions in an older white population. Arch Ophthalmol 2009; 127: 88–93
21. Gonzalez Blanco F, Sanz Fernandez JC, Munoz Sanz MA. Axial length, corneal radius, and age of myopia onset. Optom Vis Sci 2008; 85:89-96.