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Research Paper:

Estimation of Intraocular Lens Power Calculation Formula in Irregular Astigmatism With Normal Axial Length Eyes

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ABSTRACT

Background and Objectives: We evaluated the intraocular lens power calculation (IOL) formulas in eyes with cataracts and irregular astigmatism who have undergone cataract surgery.

Methods: In a retrospective case series, 50 eyes with cataracts and irregular astigmatism who underwent phacoemulsification with IOL implantation were assessed. The IOL power was determined using the data of the keratometry of IOL master-derived keratometry in five formulas: Haigis, Hoffer Q, Holladay 1, SRK2 and SRKT. One month after surgery, refractive error and visual acuity were assessed.

Results: The Mean±SD age of participants was 66.10±6.57 years (ranged 32-83). The percentage of male and female subjects was 45.8% and 54.2%, respectively. The axial length was 19.00mm to 23.00mm, which is a normal range. The most and least used formulas were SRKT and Haigis, respectively. Astigmatism and spherical refractive errors before and after surgery had significant differences (P<0.001). There was a decrease in astigmatism and hyperopic shift after surgery.

Conclusion: SRKT is a suitable formula for this group of patients. According to a decrease in astigmatism and hyperopic shift, an improvement in visual acuity can be expected.

Keywords: IOL calculation, Cataract surgery, Irregular astigmatism

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What is "already known" in this topic:

IOL calculation is based on axial length and power of cornea. Corneal power estimation in irregular astigmatism is big challenge.

What this article adds:

SRKT formula and considering the average power of cornea may be an effective approach for better IOL calculation.

Introduction

The asymmetric refractive surface of the cornea results in irregular astigmatism and/or the meridians of the cornea are not perpendicular to each other as they should be. Generally, scissor reflex on retinoscopy, monocular diplopia, and distortion of keratometric mires are seen in these patients. Cases with irregular astigmatism frequently suffer from decreased quality and quantity (visual acuity) of vision. Clinical signs consist of keratometry distortion and corneal topographic irregularity. Irregular astigmatism occurs due to corneal diseases, such as keratoconus, trauma, corneal scar following injury, Pellucid Marginal Degeneration (PMD), or Refractive Surgery, Radial Keratotomy (RK), Photorefractive Keratotomy (PRK), and Laser-assisted in Situ Keratomileusis (LASIK) [1].

Studies have shown that patients with Keratoconus (KCN) are more likely to develop cataracts at a younger age. The number of cases with KCN is increasing, leading to an increase in the number of patients who need cataract surgery [2]. Patients who have KCN and cataract simultaneously are challenging cases for surgeons. Because of irregular astigmatism, accurate keratometry and axial length measurement with the optical device are along with the challenge and as a result, the estimation of corneal power and selection of IOL power is not often accurate [3]. All standard IOL calculation formulas are based on keratometric data [4]. Limited studies have evaluated IOL power calculation in KCN eyes, yet there is no study with the most accurate IOL power calculation [5, 6]. However, Thebpatiphat et al. compared SRKT and SRKformulas in patients with KCN, and SRKⅡ formula was more favorable for mild KCN than moderate or severe KCN. There is no difference between the two formulas for moderate or severe cases [2]. Ghiasian et al. showed that the SRKⅡ formula has a good estimation for mild KCN but there is no compromise for a patient with moderate to severe KCN [7]. As a result, there is controversy about moderate to advance KCN cases. In new-generation formulas, such as Barrett and Oslen, despite the development of formulas, there is no specific calculation to correct astigmatism. In other words, the new-generation formulas have a better estimate of the postoperative sphere [8].

There is no accurate study about the selection of IOL power calculation formulas in irregular astigmatism patients; therefore, the purpose of this study was to evaluate the visual acuity and outcome after cataract surgery in patients with an irregular stigmatism. Additionally, different formulas for IOL calculation were analyzed to determine which are the most appropriate for these patients.

Materials and Methods: This study was performed on eyes with a diagnosis of irregular astigmatism and senile cataract, which underwent cataract surgery at Noor Ophthalmology Hospital in 2020.

The basis of irregular astigmatism was based on Pentacam images and misalignment of astigmatism meridians in zones 3, 5, and 7 mm. Patients with toric, multifocal lenses, previous history of cataract surgeries, and history of ocular trauma, pterygium, and corneal opacity were excluded from this study. Age and sex of patients were recorded and refraction was assessed with an Auto Kerato-Refractometer (Nideck, ARK 510 A). Biometry measurements of these individuals were performed with IOL Master 500 (Carl Zeiss) and if SNR was not acceptable, IOL Master 700 (Meditec AG) was used. Based on IOL master keratometry data, IOL power calculation was performed using five known formulas, SRK2, SRKT, Holladay 1, Hoffer Q Q, and Haigis. IOL information was evaluated using patients' records. Patients were revisited for complete ocular and optometric examinations one day, seven days, and one month after the surgery,

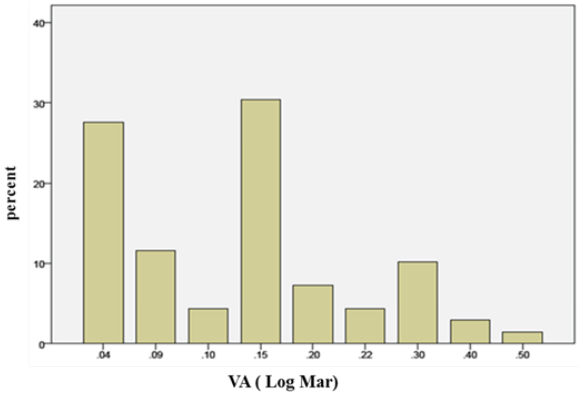

Figure 1. Mean visual acuity (log MAR) in patients with irregular astigmatism after cataract surgery

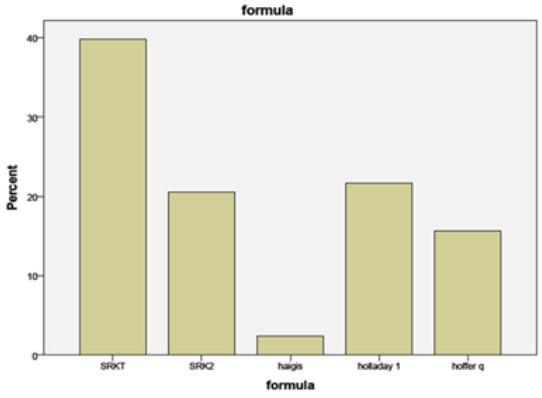

Figure 2. Percentage of using different formulas in individuals with irregular astigmatism and cataracts (n=50)

and the patients' final refraction and visual acuity were recorded one month after the surgery. Visual acuity and refractive error after surgery were considered as criteria for the superiority of the formulas over each other. SPSS software v. 21 was used for data analysis. In this study, a significance level of 0.05 was considered.

Results

This study was performed on 50 eyes in patients with irregular astigmatism and cataracts with a Mean±SD age of 66.6±10.57 years, of whom 45.8% were men and 54.2% were women. They had a normal axial length of less than 23 mm and more than 19 mm. At one month postoperative visit, an increase in visual acuity was observed in all patients. The mean visual acuity in patients after cataract surgery was 0.14 (Log MAR). About 23% of people with visual acuity with (log MAR) 0.4 and about 34%, had better vision than 0.15 (Log MAR) (Figure 1).

According to the used formulas and analysis, Figure 2 shows that the SRKT formula was the most used formula in patients (about 40%) and the Haigis formula was the least used and after the SRKT formula, Holladay 1 formula was the most used formula.

Figures 3 and 4 show the amount of astigmatism before and after cataract surgery in patients. The Mean±SD of preoperative astigmatism was 3.11±1.09 and the Mean±SD of postoperative astigmatism is 2.71±0.98. Also, the mean preoperative sphere regardless of the formulas was 0.13±1.83 and the postoperative sphere was 0.91±0.70. There was a tendency for hyperopic shifts in the postoperative sphere.

Using the t-test, there was a significant difference between preoperative and postoperative astigmatism as well as preoperative and postoperative spheres (P<0.001).

Comparison of postoperative spheres between different formulas showed that among the assessed formulas, the results of the Haigis formula were significantly different from Holladay 1, SRKT, Hoffer Q, and SRK2 formulas (P<0.05).

Discussion

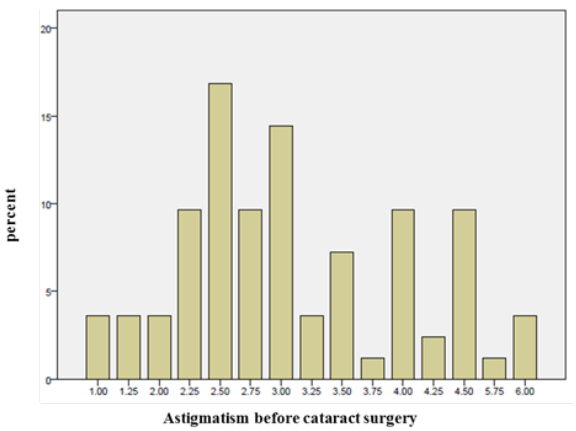

Figure 3. Percentage of astigmatism before cataract surgery in individuals with irregular astigmatism and cataracts (n=50)

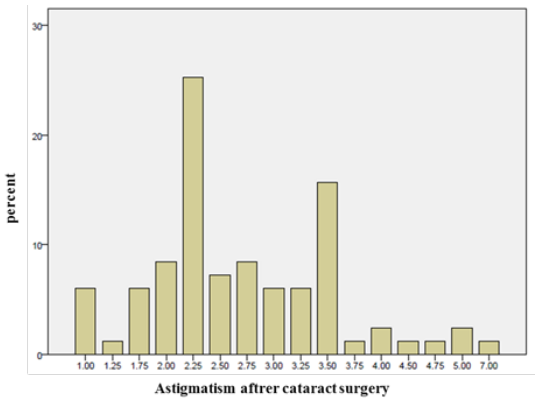

Figure 4. Percentage of astigmatism after cataract surgery in individuals with irregular astigmatism and cataracts (n=50)

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Calculating the power of the IOL in the eyes with irregular astigmatism is challenging and leads to a decrease in predictable strength. Most IOL calculation formulas are based on normal people or at least people with normal eye optics. There is little information on eyes with irregular stigmatism because of the challenging nature of the calculation of IOL [5].

According to the results of this study, with cataract surgery and IOL implantation, in individuals with irregular astigmatism, visual acuity improved. There is also a refractive hyperopic shift after cataract surgery in these individuals, which averaged 0.75D. This finding is consistent with previous studies [9, 10].

Despite the fact that modern formulas have many variables to increase the accuracy of calculating the power of IOL, regression formulas still have more acceptable results in these individuals [11]. It is said that one of the reasons for the hyperopic shift is that the corneal refractive index and its power are calculated due to the irregularity of the cornea, which is effective in estimating the power of the calculated IOL and ultimately leads to hyperopic shifts [12, 13].

In all formulas in this study, the postoperative spherical equivalent was used. Watson et al., 43.25 D was considered as a fixed value for keratometry during the calculation of intraocular lens power in individuals with severe keratoconus, which caused the amount of postoperative refractive defects to be significantly different from the predicted amount [5, 9, 10]. Because corneal power is very effective in calculating IOL power and posterior parts of the cornea is not measurable by routine methods and the presence of irregularities in the posterior part of the cornea causes incorrect estimation of the power of IOL [9], using devices, such as Pentacam or videokeratography by providing maps, such as true net power, equivalent K reading or AS-OCT, the exact amount of corneal power can be calculated and the amount of computational error of intraocular lens power can be reduced to some extent [6, 7].

Generally, with increasing irregularity in the cornea, the rate of postoperative hyperopia increases. Another factor in the increase in postoperative hyperopia in these patients is that the value of A constant is optimized for these patients, which makes it difficult to calculate the power of the IOL in individuals [9, 10]. Future studies in this field should find a suitable A constant in these individuals. On the other hand, asymmetric corneal power and the abnormal relationship between corneal curvature and anterior chamber depth in these individuals, especially patients with KCN, disrupts the estimation of IOL position, which reduces the accuracy of IOL formulas in predicting the effective position of the lens [12, 13]. Although calculating the power of IOL in people with irregular corneas is still challenging, the results of this study showed that the SRK T formula was the most common formula compared to other formulas, and since the results are satisfactory, this formula has the highest percentage of use.

In this study, there was a significant difference between the different formulas after the operation spherical result [14]. This finding depends on the fact that the SRKT formula tends to overestimate the power of IOL in steep corneas, as recently expressed by Melles et al. [15]. Such overestimate can be useful in eyes with keratoconus because it can balance the tendency towards hyperopia observed with most formulas.

Previous studies have shown that in individuals with keratoconus (especially mild), the SRKT formula is more accurate [7, 9, 10]. However, a formula called Kane Keratoconus was used in keratoconus patients, which reduced the IOL power prediction error by 20 to 39 percent [18]. On the other hand, although the SRK T formula can have higher accuracy than other formulas, especially in eyes with shorter axial length, according to Wang et al., the Barrett Universal II formula is more accurate in calculating the intraocular lens of keratoconus patients with longer axial length [19].

The SRK T, Hoffer Q, and Holladay formulas also indirectly calculate the effective position of the lens in the posterior chamber. The higher the amount of keratometry and axial length, the greater the depth of the anterior chamber and the further back the position of the intraocular lens is estimated, which can cause more refractive hyperopia in patients after surgery [7].

According to the findings of this study, postoperative astigmatism was significantly different in patients, and also according to the existing conditions, there is a hyperopic shift and the visual acuity of the people improved moderately. It can be concluded that when astigmatism decreases to some extent and people become hyperopic, CLC falls on the retina and although having spherical IOL, visual acuity improves in these individuals.

Conclusion

When individuals with irregular astigmatism use spherical IOL and some astigmatism remains, it is recommended that they have 0.5 to 0.75 D hyperopic shifts. In people with keratoconus and irregular astigmatism, we will not

have very good vision, but by choosing the right formula and making individuals somewhat hyperopic, postoperative vision conditions can be improved to some extent.

Ethical Considerations

Compliance with ethical guidelines

This study was approved by the Ethics Committee of the University of Iran University of Medical Sciences (IUMS), (Code: IR IUMS.REC.1397601–12/4/97).

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Authors' contributions

Conceptualization, Supervision, Investigation, and Writing – review & editing: All authors. Writing – original draft, and Funding acquisition, Resources: Leila mirzaee Saba and Ebrahim Jafarzadehpour.

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References

[1] Koh S. Irregular astigmatism and higher-order aberrations in eyes with dry eye disease. Invest Ophthalmol Vis Sci. 2018; 59(14):DES36-40. [DOI:10.1167/iovs.17-23500] [PMID]

[2] Thebpatiphat N, Hammersmith KM, Rapuano CJ, Ayres BD, Cohen EJ. Cataract surgery in keratoconus. Eye Contact Lens. 2007; 33(5):244-6. [DOI:10.1097/ICL.0b013e318030c96d] [PMID]

[3] Leccisotti A. Refractive lens exchange in keratoconus. J Cataract Refract Surg. 2006; 32(5):742-6. [DOI:10.1016/j.jcrs.2006.01.063] [PMID]

[4] Cua IY, Qazi MA, Lee SF, People JS. Intraocular lens calculations in patients with corneal scarring and irregular astigmatism. J Cataract Refract Surg. 2003; 29(7):1352-7. [DOI:10.1016/S0886-3350(03)00227-X]

[5] Watson MP, Anand S, Bhogal M, Gore D, Moriyama A, Pullum K, et al. Cataract surgery outcome in eyes with keratoconus. Br J Ophthalmol. 2014; 98(3):361-4. [PMID]

[6] Tamaoki A, Kojima T, Hasegawa A, Nakamura H, Tanaka K, Ichikawa K. Intraocular lens power calculation in cases with posterior keratoconus. J Cataract Refract Surg. 2015; 41(10):2190-5. [DOI:10.1016/j.jcrs.2015.11.001] [PMID]

[7] Ghiasian L, Abolfathzadeh N, Manafi N, Hadavandkhani A. Intraocular lens power calculation in keratoconus: A review of literature. J Curr Ophthalmol. 2019; 31(2):127-34. [DOI:10.1016/j.joco.2019.01.011] [PMID] [PMCID]

[8] Roberts TV, Hodge C, Sutton G, Lawless M; contributors to the Vision Eye Institute IOL outcomes registry. Comparison of Hill-radial basis function, Barrett Universal and current third generation formulas for the calculation of intraocular lens power during cataract surgery. Clin Exp Ophthalmol. 2018; 46(3):240-6. [DOI:10.1111/ceo.13034] [PMID]

[9] Savini G, Abbate R, Hoffer KJ, Mularoni A, Imburgia A, Avoni L, et al. Intraocular lens power calculation in eyes with keratoconus. J Cataract Refract Surg. 2019; 45(5):576-81. [DOI:10.1016/j.jcrs.2018.11.029] [PMID]

[10] Kamiya K, Iijima K, Nobuyuki S, Mori Y, Miyata K, Yamaguchi T, et al. Predictability of intraocular lens power calculation for cataract with keratoconus: A multicenter study. Sci Rep. 2018; 8(1):1312. [DOI:10.1038/s41598-018-20040-w] [PMID] [PMCID]

[11] Kane JX, Connell B, Yip H, McAlister JC, Beckingsale P, Snibson GR, et al. Accuracy of intraocular lens power formulas modified for patients with keratoconus. Ophthalmology. 2020; 127(8):1037-42. [DOI:10.1016/j.ophtha.2020.02.008] [PMID]

[12] Piñero DP, Camps VJ, Caravaca-Arens E, Pérez-Cambrodí RJ, Artola A. Estimation of the central corneal power in keratoconus: Theoretical and clinical assessment of the error of the keratometric approach. Cornea. 2014; 33(3):274-9. [DOI:10.1097/ICO.0000000000000048] [PMID]

[13] Kamiya K, Kono Y, Takahashi M, Shoji N. Comparison of simulated keratometry and total refractive power for keratoconus according to the stage of Amsler-Krumeich classification. Sci Rep. 2018; 8(1):12436. [DOI:10.1038/s41598-018-31008-1] [PMID] [PMCID]

[14] Hashemi H, Heidarian S, Seyedian MA, Yekta A, Khabazkhoob M. Evaluation of the results of using toric IOL in the cataract surgery of keratoconus patients. Eye Contact Lens. 2015; 41(6):354-8. [PMID]

[15] Melles RB, Holladay JT, Chang WJ. Accuracy of intraocular lens calculation formulas. Ophthalmology. 2018; 125(2):169-78. [DOI:10.1016/j.ophtha.2017.08.027] [PMID]

[16] Hoffer KJ, Savini G. IOL power calculation in short and long eyes. Asia Pac J Ophthalmol (Phila). 2017; 6(4):330-1. [PMID]

[17] Celikkol L, Ahn D, Celikkol G, Feldman ST. Calculating intraocular lens power in eyes with keratoconus using video keratography. Cataract Refract Surg. 1996; 22(4):497-500. [DOI:10.1016/S0886-3350(96)80049-6]

[18] Bhutani G, Thulasidas M, Gupta H. Re: Kane et al.: Accuracy of intraocular lens power formulas modified for patients with keratoconus (Ophthalmology. 2020; 127:1037-42). Ophthalmology. 2021; 128(2):e12-3. [DOI:10.1016/j.ophtha.2020.09.018] [PMID]

[19] Wang KM, Jun AS, Ladas JG, Siddiqui AA, Woreta F, Srikumaran D. Accuracy of intraocular lens formulas in eyes with keratoconus. Am J Ophthalmol. 2020; 212:26-33. [DOI:10.1016/j.ajo.2019.11.019] [PMID]

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مقاله پژوهشی

تخمین فرمول قدرت لنز داخل چشمی در چشم‌های با طول محوری طبیعی و آسیگماتیسم نامنظم

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چکیده

مقدمه فرمول‌های محاسبه لنزهای داخل چشمی در بیماران دارای کاتاراکت با آستیگماتیسم نامنظم در این مقاله مورد بررسی قرار می‌گیرد.

مواد و روش‌ها این مطالعه بر روی ۵۰ چشم در بیماران با آستیگمات نامنظم و کاتاراکت که تحت جراحی فیکو و کاشت لنز داخل چشمی قرار گرفتند، انجام شد. محاسبه قدرت لنزهای داخل چشمی بر اساس داده‌های کراتومتری IOL Master و توسط ۵ فرمول Hoffer Q, Haigis, SRKT, SRK2 , Holladay انجام شد.

یافته‌ها در این مطالعه، میانگین سنی۶/۵۷±۶۶/۱۰ بود که ۴۵/۸ درصد آنان را مردان و ۵۴/۲ درصد زنان تشکیل می‌دادند. افراد دارای طول محوری نرمال کمتر از ۲۳ میلی‌متر و بیشتر از ۱۹ بودند. فرمول SRKT بیشترین کاربرد و فرمول Haigis کمترین کاربرد را در این نمونه‌ها داشته است. نتایج آستیگماتیسم و اسفر بعد از عمل در مقایسه با قبل از عمل، تفاوت معناداری نشان داد (P<۰/۰۰۱). همچنین کاهش آستیگماتیسم و شیفت هایپروپی در اسفر بعد از عمل وجود داشت.

نتیجه‌گیری فرمول SRKT، فرمول مناسبی در افراد با آستیگمات نامنظم و کاتاراکت است و با وجود کاهش آستیگماتیسم بعد از عمل و شیفت هایپروپی، بهبود حدت بینایی بعد از عمل قابل انتظار است.

کلیدواژه‌ها:
محاسبه IOL،
جراحی آب مروارید،
آستیگماتیسم نامنظم

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