Original Article

The Comparative Study of Refractive Index Variations between Haigis, Srk/T and Hoffer-Q Formulas Used for Preoperative Biometry Calculation in Patients with the Axial Length >25 mm

Hasan Razmjoo, Hosein Atarzadeh, Neda Kargar, Mohammad Behfarnia, Kobra Nasrollahi, Ali Kamali

From the Department of Ophthalmology, Isfahan University of Medical sciences, Isfahan, Iran

Abstract

Background: To compare refractive index variation between Hoffer-Q, Haigis and SRK/T formulas used for preoperative biometry calculation in patients with axial length >25 mm, undergoing cataract surgery. **Materials and Methods:** This is a randomized clinical trial study was performed on 54 eyes of 54 patients with ages of 40–70 years old and axial length >25 mm classified into three groups that their IOL POWER were calculated by Haigis, SRK/T and Hoffer-Q formulas before undergoing cataract surgery. Their refractive index variations were calculated from the difference between predicted refractive error formula and actual post-operative refractive error formula. The collected data was entered in SPSS software and was analyzed by ANOVA and Chi-square statistical test. **Results:** With comparison sphere, astigmatism and spherical equivalent indexes before and after of cataract surgery between Haigis, SRK/T, and Hoffer-Q formulas, statistically significant differences were found between the mean of sphere and SE indexes in patients with use of Haigis and SRK/T formulas that have been more favorable post-operative refraction. **Conclusions:** Haigis formula and then, with slight difference, SRK/T formula have better and more acceptable post-operative refraction results than Hoffer-Q formula in patients with high axial myopia. Therefore, it is recommended using Haigis and SRK/T formulas for IOL power calculation in patients with high axial myopia undergoing cataract surgery.

Keywords: *Cataract surgery, high myopia, IOL power calculation formula*

Introduction

In addition to the arthritis and the heart diseases, the cataract is one of the most common causes of disability in the elderly. The prevalence of cataract in people over 40 years in the United States, 20.5 million individuals, 23.3% of individuals over 50 years in China and 32%, 96.9% and 100% of individuals over 40, 70 and 80 years old, respectively, in Japan have been reported.[1] According to the WHO, the cataract has caused the 27 to 45 million of blindness in the world.[2]

The cataract surgery is the most common eye surgery in the world and in 98% of this surgery, the intraocular lens (IOL) has been used. Between all aphakia methods, the IOLs are easier and have better performance in terms of eyesight. In the last decade, there were significant improvements in the accuracy with which the surgeon able to correct refractive errors by surgery and to achieve emmetropia.

The development of advanced instruments for measuring the axial length (AL) and using the precise mathematical formulas to calculate the IOLs power have helped to these improvements.[3]

Precise biometry, phacoemulsification surgery and formulas for determining the IOLs power lead to reduction of refractive errors after the cataract surgery. The most important step for an accurate calculation of the IOL power is the preoperative measurement of the ocular axial length.[4]

Accurate measurement of the eye axial length is performed with ultrasound development in the optical biometry, and third-generation new formulas (SRK/T formula, Holladay I formula and Hoffer Q formula) are based on measurement of corneal power and the axial length.

The post-operative lens position determination mechanism has a certain formula and is based on the axial length and the keratometry. The

How to cite this article: Razmjoo H, Atarzadeh H, Kargar N, Behfarnia M, Nasrollahi K, Kamali A. The Comparative Study of Refractive Index Variations between Haigis, Srk/T and Hoffer-Q Formulas Used for Preoperative Biometry Calculation in Patients with the Axial Length >25 mm. Adv Biomed Res 2017;6:78.

Received: May, 2014. **Accepted:** August, 2014.

Address for correspondence:
Dr. Neda Kargar,
Department of Ophthalmology, Feiz Hospital, Isfahan University of Medical sciences, Isfahan, Iran.
E-mail: drnkargar@gmail.com

Access this article online

Website: www.advbiores.net

DOI: 10.4103/2277-9175.210657

Quick Response Code:

formulas for measurement of the IOLs power are classified into four generations. The first generation of formulas is theoretical and based on the same fundamental constant and regardless of anterior chamber depth. The second generation was designed by combining linear regression analysis and stepwise adjustment for long and short eyes according to anterior chamber depth. The third- and fourth-generation formulas, all aimed at better calculation of the IOL power in eyes with extreme axial length. The accuracy of third- and fourth-generation formulas had not been fully evaluated in patients with high axial myopia, in which the need for more studies conducted in this field is crucial.[5]

New formulas, Holladay II formula and Haigis formula, have some other variables for calculating the IOL power such as: The anterior chamber depth, the lens thickness, the pre-operative refraction errors and the effective IOLs position. These improvements are used for the selection of the fittest IOL power.[6] The Holladay II formula uses the theoretical vergence formula to calculate the IOL power. This formula uses seven variables including keratometry, ocular axial length, horizontal corneal diameter or horizontal WTW (horizontal white to white), anterior chamber depth, lens thickness, age and refraction.[7-9] According to different studies with different results, lack of similar studies in Iran, and in accordance to determine the appropriate formula is an important factor for obtaining the best result in the cataract surgery, especially in individuals with high axial length; this study was done to compare the refractive index variation between Hoffer-Q formula, Haigis formula and SRK/T formula used for preoperative biometry calculation in patients with the axial length higher than 25 mm undergoing the cataract surgery.

Materials and Methods

This is a randomized clinical trial study that was performed in eye clinic of the Feiz hospital affiliated to Isfahan University of Medical Sciences during years 2012–2013. The statistical population of this study includes patients who had cataract surgery in the mentioned clinic.

The inclusion criteria of this study were including: The ages of 40–70 years old, the axial length >25mm that was measured with a IOL MASTER 500 ZEISS Biometer, the preoperative corneal cylinder value between 0 and –1.5 diopter, the existence of age-related cataract confirmed by ophthalmologist, no previous surgery of anterior or posterior segment in the same eye and finally, patient's consent for study. The exclusion criteria included non-correctable retinal and corneal problems affecting vision, other eye pathologies except cataract, surgical-related complication during surgery and post-operation and inaccessibility to patients after operation due to lack of comeback to clinic for re-visiting after surgery.

The sample size required for the study was estimated by the use of the "sample size estimation formula for comparison of mean" values. Moreover, some other factors were included for determining sample size, they are reliability of 95%, test power of 80% and refraction variation of 0.75 as obtained from other studies and the least significant differences between the two groups was considered as 0.8. Considering these items, the sample size was estimated at 18 individuals in each group. The patient examined by ophthalmologist and after earning the necessary criteria were enrolled to the study and filled out the consent form. Initially, a profile was prepared for each patient. Some questions were asked from patients for filling the form: Visual history before cataract, use or not use of glasses, previous eye examination, age, gender, right or left eye, address, and telephone number, and recorded by ophthalmologist and residents of ophthalmology in their profiles. For all patients complete ocular examination was performed before operation including visual acuity, intraocular pressure (IOP) measurement, slit-lamp examination, fundoscopy and cycloplegic auto-refraction. The patients undergo biometry by IOL MASTER 500 ZEISS Biometer under the supervision of a qualified person in the Feiz eye clinic. Then patients with AL >25 mm, randomly classified into three groups. The first, second and third patients were classified respectively in Haigis, SRK/T and Hoffer-Q groups, and other patients were distributed in the three consecutively groups until the sample size was completed. Haigis formula, SRK/T formula and Hoffer-Q formula were used respectively in first, second and third groups to calculate the IOL power. Experienced surgeons performed all operation using standard phacoemulsification through a 3.2 mm clear cornea tunnel incision without suture. Phacoemulsification was followed by in the bag implantation of IOL. After that, the patients underwent the supportive care and were discharged if possible. Patients were followed up for examination in the first and second days and then weekly until the first month and also monthly for 3 months after surgery. One and 3 months after surgery, cycloplegic auto-refraction was measured again for each patient and recorded in their profiles.

The collected data was entered in SPSS software version 22 and was analyzed by ANOVA and Chi-square statistical test.

Results

In this study 54 volunteers for cataract surgery with AL >25 mm were randomly classified in three groups of 18 individuals and were studied. The mean patient age in the Hoffer-Q, SRK/T, and Haigis groups were 65.1 ± 7.5, 58 ± 14.9, and 65.9 ± 12.1 respectively and there were no statistically significant difference between the three groups (P = 0.1). The gender ratio (male to female) in the three mentioned groups were 11/7, 7/11 and 5/13 respectively, and there was no significant difference between them (P = 0.12) [Table 1].

The axial length means in the Hoffer-Q, the SRK/T and the Haigis groups were 26.42 ± 1.22, 27.11 ± 1.55 and

Table 1: Demographic data between three groups

Groups / Variables	Hoffer-Q	SRK/T	Haigis	*P*
Age (year)	58±14.9	65.1±7.5	65.9±12.1	0.1
Sex				
Male	7 (38.9%)	11 (61.1%)	5 (27.8%)	0.12
Female	11 (61.1%)	7 (38.9%)	13 (72.2%)	
Axial length (mm)	27.11±1.55	26.42±1.22	27.68±1.94	0.07
IOL (diopter)	6.86±4.58	11.75±2.48	7.86±5.17	0.003

SRK/T: Sanders, Retzlaff, Kraff Formula, IOL: Intraocular lens

27.68 ± 1.94 and statistically significant difference was not seen (P = 0.07) [Figure 1].

The mean IOL power indexes in the three mentioned groups were 11.75 ± 2.48, 6.86 ± 4.58 and 7.86 ± 5.17, respectively, and the statistical difference between them was significant (P = 0.003) [Figure 2].

The mean and SD of three parameters include sphere, spherical equivalence and astigmatism, before and after surgery, are shown in Figure 2. The mean of spherical index before surgery in the Hoffer-Q, the SRK/T and the Haigis groups were –10.87 ± 2.92, –11.31 ± 3.17 and –10.58 ± 4.86 diopter, respectively. According to the ANOVA analysis, there were no statistically significant difference between them (P = 0.85). But after surgery there was statistically significant difference between the mean of sphere index in the mentioned groups, which were –2.21 ± 1.23, –0.24 ± 0.68 and –0.07 ± 0.85, respectively (P < 0.001) [Figure 3]. The difference of mean of sphere index in the three above groups were –8.66 ± 3.05, –11.07 ± 3.10 and –10.51 ± 4.98, respectively and were seen no statistically significant difference between the three groups (P = 0.15) [Table 2].

The mean of Astigmatism index before operation in the Hoffer-Q, the SRK/T and the Haigis groups were –0.64 ± 0.75, –1.04 ± 0.29 and –0.94 ± 0.37. According to mentioned test, the difference between the three groups were not statistically significant (P = 0.06).

After operation the mean of the astigmatism in these three groups were –0.83 ± 1.49, –0.88 ± 1.57 and -0.78 ± 1.48 and the difference between them were not statistically significant (P = 0.98) [Figure 4]. The difference of mean of the astigmatism index in these three groups were 0.19 ± 1.68, –0.17 ± 1.67 and –0.17 ± 1.55 which were not statistically significant difference (P = 0.75). The spherical equivalent mean of the three groups before surgery were –11.19 ± 3.01, –11.83 ± 3.19 and –11.06 ± 4.94 respectively and the difference between them were not statistically significant (P = 0.81). After surgery, the mean of the SE of these three groups were –2.63 ± 1.31, –0.67 ± 1.11 and –0.46 ± 1.39 which were statistically significant difference between the three groups (P < 0.001) [Figure 5].

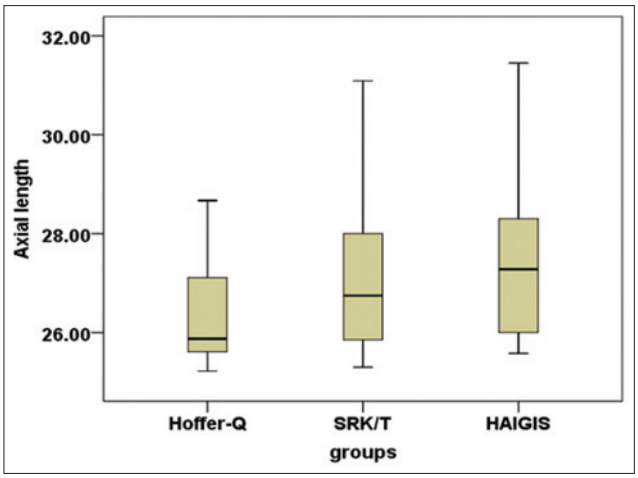

Figure 1: Median, range, 25th and 75th percentiles of ant-post ocular axial length in the three used methods

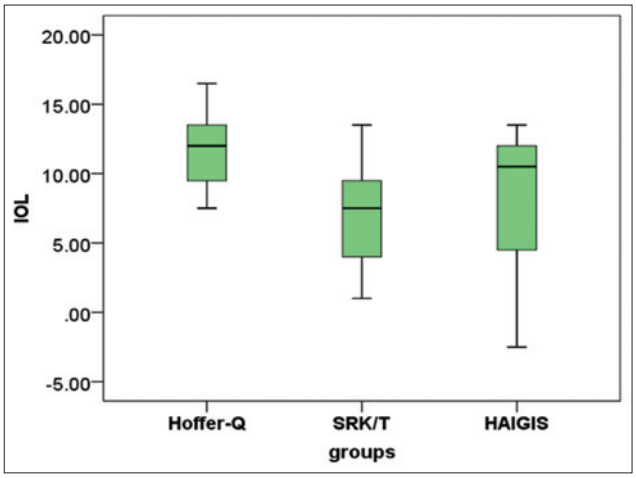

Figure 2: Median, range, 25th and 75th percentiles of the IOL power in the three used methods

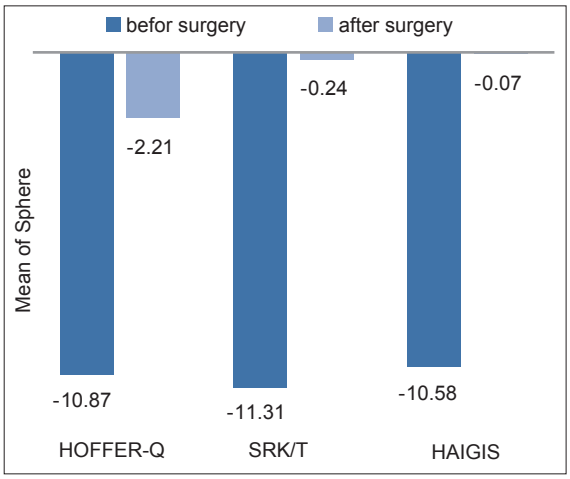

Figure 3: The mean of sphere index in the three groups before and after surgery

The difference of mean of the SE index in the three studied groups that were –8.56 ± 3.27, –11.15 ± 3.24

Table 2: The mean±SD of sphere, astigmatism and SE indexes before and after surgery

Indexes	Groups time	Hoffer-Q	SRK/T	Haigis	*P*
Sphere	Before surgery	−10.87±2.92	−11.31±3.17	−10.58±4.86	0.85
	After surgery	−2.21±1.23	−0.24±0.68	−0.07±0.85	<0.001
	Difference of mean of sphere index	−8.66±3.05	−11.07±3.10	−10.51±4.98	0.15
Astigmatism	Before surgery	−0.64±0.75	−1.04±0.29	−0.94±0.37	0.06
	After surgery	−0.83±1.49	−0.88±1.57	−0.78±1.48	0.98
	Difference of mean of astigmatism index	0.19±1.68	−0.17±1.67	−0.17±1.55	0.75
Spherical equivalent	Before surgery	−11.19±3.01	−11.83±3.19	−11.06±4.94	0.81
	After surgery	−2.63±1.31	−0.67±1.11	−0.46±1.39	<0.001
	Difference of mean of SE index	−8.56±3.27	−11.15±3.24	−10.60±5.26	0.13

SD: Standard deviation, SE: Standard error, SRK/T: Sanders, Retzlaff, Kraff Formula

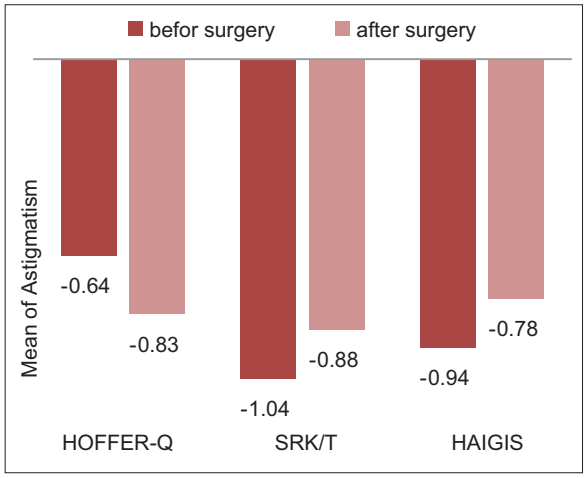

Figure 4: The mean of astigmatism index in the three groups before and after surgery

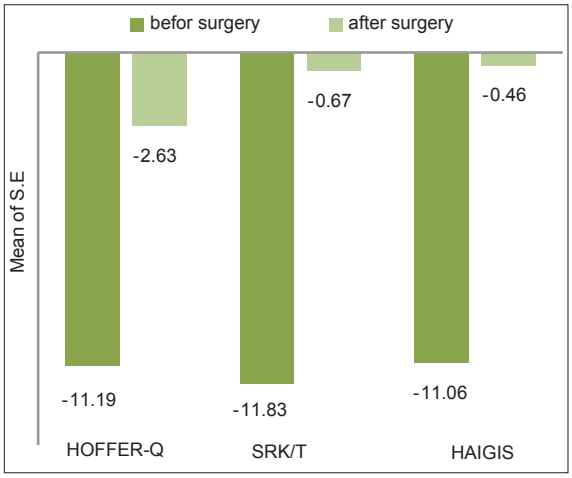

Figure 5: The mean of SE index in the three groups before and after surgery

and –10.60 ± 5.26, respectively ($P = 0.13$), showed that there were not statistically significant difference between them. Figure 6 demonstrates the difference of mean of the three mentioned indexes in these groups before and after surgery.

Discussion

The overall objective of this study was to compare refractive errors after cataract surgery between Hoffer-Q formula, Haigis formula and SRK/T formula calculated in biometry before cataract surgery in patients with the axial length >25 mm. In this study there were no significant differences in terms of age and gender distributions between three investigated groups. Therefore, the confounding effect of these factors in this study neutralized.

According to the results, there was no statistically significant difference in mean of the axial length between the Hoffer-Q, the SRK/T and the Haigis groups. In the investigation of parameters related to refraction included sphere, SE and astigmatism, in the preoperative, no significant differences were observed between the three groups. But after operation, there were statistically significant differences between the mean of sphere and SE indexes. The patients undergoing the cataract surgery with the use of Haigis formula and SRK/T formula had a more favorable postoperative refraction. These results are consistent with the Raouf,[5] the Mona Mohammad,[10] the Reuland[11] and the Priti[12] studies, so that the Raouf study which was done on 53 myopic eyes with the axial length between 25.5 to 31.4 mm, in terms of refractive errors after cataract surgery, there was no statistically significant difference between SRK/T formula and Haigis formula.[5]

Furthermore, the Mona Mohammad study was done on 50 high myopic eyes, no statistically significant difference between SRK/T formula and Haigis formula was found; but both mentioned formulas were better than Hoffer-Q formula[10] which is similar to this study. In the Reuland study which was carried out on 86 high myopia eyes with the axial length >28 mm, Haigis formula and SRK/T formula were more accurate than Hoffer-Q formula and Holladay formula.[11] Also, Hoffer-Q formula and Holladay formula led to myopic refractive errors that were observed in this study.

The Priti study was done on 80 myopic eyes, SRK/T formula and then, with slight difference, Haigis formula were the best formulas for eyes with the axial length >24 mm.[12] Other study was carried out by Petermeier on 50 high myopia eyes, there was no statistically significant difference between Hagis formula, SRK/T formula and Hoffer-Q formula in post-operative refraction.[13] Also, in the Nemeth study was done on 40 eyes with the axial length >31 mm,

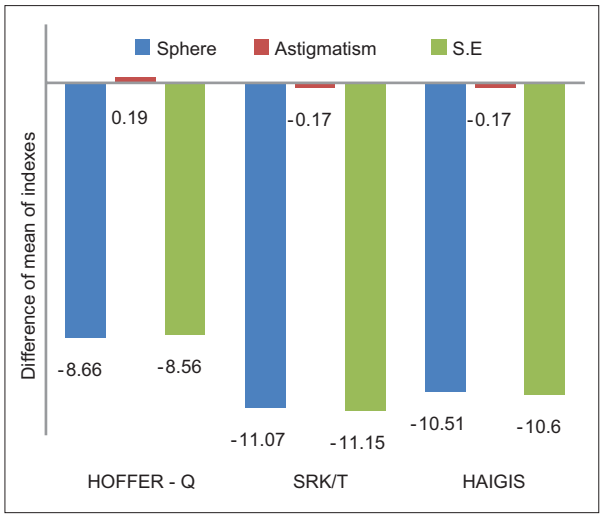

Figure 6: The difference of mean of sphere index, astigmatism index and SE index in the three groups before and after surgery

no statistically significant difference found between three mentioned formulas and achieved satisfactory results.[14] In some other studies, the postoperative refraction results have been more favorable with using Haigis formula. For example, the Asad study was done on 127 myopic eyes with the axial length >26 mm, Haigis formula compared with Hoffer-Q formula and Holladay II formula was the best known.[15-17] As well as, the Jia-Kang study was done on 68 eyes with the axial length >25 mm, the precision of Haigis formula was better than the other formulas.

Considering the results obtained in this study and comparison with other studies, it can be concluded that although the all three formulas, Haigis, Hoffer-Q and SRK/T, are the new and advanced formulas for the IOL power measurement in patients with high myopia but Haigis formula and then, with slight difference, SRK/T formula have better and more acceptable post-operative refraction results than Hoffer-Q formula in patients with high axial length. Therefore, it is recommended using Haigis formula and SRK/T formula for the IOL power calculation in patients with high axial myopia undergoing cataract surgery.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Javadi MA, Rezaei A, Karimian F, Amini H, Pakravan M, Mahdavinouri K, *et al*. Prevalence of cataract in people above 40 years old resident in Tehran. Bina J Ophthalmol 2004; 9:309-17.
2. Soudi S, editor. Cataract. Tehran: Hayan-Abasaleh; 2006. 89-91.
3. Johns KJ, Feder RS, Hamill MB, Miller-Meeks MJ, Rosenfeld SI, Perry PE. Evaluation and management of cataract in adult. In: Liesegang TJ, Deutsch TA, Grand MG, editors. Basic and Clinical Science Course; Section 11: Lens and Cataract. New York: American Academy of Ophthalmology; 2004. p. 149-250.
4. Eleftheriadis H. IOL master biometry: Refractive results of 100 consecutive cases. Br J Ophthalmol 2003; 87:960-3.
5. El-Nafees R, Moawad A, Kishk H, Gaafar W. Intra-ocular lens power calculation in patients with high axial myopia before cataract surgery. Saudi J Ophthalmol 2010; 24:77-80.
6. Terzi E, Wang L, Kohnen T. Accuracy of modern intraocular lens power calculation formulas in refractive lens exchange for high myopia and high hyperopia. J Cataract Refract Surg 2009; 35:1181-9.
7. Koch DD, Wang L. Calculating IOL power in eyes that have had refractive surgery. J Cataract Refract Surg 2003; 29:2039-42.
8. Bang S, Edell E, Yu Q, Pratzer K, Stark W. Accuracy of intraocular lens calculations using the IOLMaster in eyes with long axial length and a comparison of various formulas. Ophthalmology 2011; 118:503-6.
9. MacLaren RE, Natkunarajah M, Riaz Y, Bourne RR, Restori M, Allan BD. Biometry and formula accuracy with intraocular lenses used for cataract surgery in extreme hyperopia. Am J Ophthalmol 2007; 143:920-31.
10. Farag MM, Atwa FA. Haigis and SRK/T formulas for intraocular lens power calculation in high myopia. Menoufiya Med J 2011;24:155-60.
11. Reuland AJ, Neens N, Holzer MP, Rabsilber TM, Limberger IJ, Auffarth GU. Calculation of Intraocular Lens Power for High Myopia. 15th SOE Congress and 103rd DOG Congress. Berlin, Germany: Springer; 2005. p. 346.
12. Kapadia P, Dalal N, Patel N, Chauhan MD. Intraocular lens power calculation formulas in high refractive errors… what to choose and when? Natl J Integr Res Med 2013; 4:33-6.
13. Petermeier K, Gekeler F, Messias A, Spitzer MS, Haigis W, Szurman P. Intraocular lens power calculation and optimized constants for highly myopic eyes. J Cataract Refract Surg 2009;35:1575-81.
14. Nemeth G, Nagy A, Berta A, Modis L Jr. Comparison of intraocular lens power prediction using immersion ultrasound and optical biometry with and without formula optimization. Graefes Arch Clin Exp Ophthalmol 2012; 250:1321-5.
15. Ghanem AA, El-Sayed HM. Accuracy of intraocular lens power calculation in high myopia. Oman J Ophthalmol 2010;3:126-30.
16. Wang JK, Chang SW. Optical biometry intraocular lens power calculation using different formulas in patients with different axial lengths. Int J Ophthalmol 2013; 6:150-4.
17. Wang JK, Hu CY, Chang SW. Intraocular lens power calculation using the IOLMaster and various formulas in eyes with long axial length, J Cataract Refract Surge 2008;34:262-7.