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Comparison of preoperative and postoperative intraocular lens power values in eyes with Keraring implantation

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圆锥角膜基质环植入手术前后人工晶状体度数的比较

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摘要

目的:评估圆锥角膜基质环(keraring 355°)(ICRS)植入术前术后3mo 人工晶状体(IOL)度数的计算和生物学特征。

方法:队列研究。收集18 例(19 眼)圆锥角膜接受角膜基质环植入术患者术前及术后3mo 数据。分析裸眼视力(UCVA),最佳矫正视力(BCVA),屈光度,人工晶体度数计算公式,眼轴长度(AL)和角膜曲率。

结果:患者平均年龄为 29.58±0.6y。裸眼视力由 0.84(0.35) LogMAR 显著提高到 0.43 (0.31) LogMAR ($P<0.001$)。3mo 后,最佳矫正视力和眼轴长度无明显变化。球镜度数,柱镜度数和等效球镜(SE)均显著提高 ($P<0.001$)。另一方面,角膜曲率 1(K1)和角膜曲率 2(K2)显著下降。3mo 后, SRK/II ($P<0.001$), Hoffer Q ($P<0.001$) and Holladay I ($P<0.001$)发生显著变化。

结论:角膜基质环植入术后,视力,屈光率和角膜曲率均有所提高,此外,人工晶状体计算公式度数明显改变。然而,角膜基质环植入术过程没有过度干预眼轴长,但降低角膜曲率值使得人工晶状体度数计算更加精确,所有公式得出同一晶状体度数。

关键词:人工晶状体;角膜基质环;圆锥角膜

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Abstract

• AIM: To evaluate intraocular lens power (IOL) calculation and biometry before and 3mo after implantation of Keraring 355° intrastromal corneal ring segment (ICRS; Mediphacos, Belo Horizonte, Brazil) in keratoconic eyes.

• METHODS: In this cohort study, data of 19 keratoconus eyes of 18 patients which undergone ICRS implantations were gathered before and 3mo after surgery. Uncorrected visual acuity (UCVA), best corrected visual acuity (BCVA), manifest refraction, IOL power calculation formulas, axial lenght (AL) and keratometry were analayzed.

• RESULTS: Mean age of participants was 29.58±0.6. UCVA improved from 0.84 (0.35) logMAR to 0.43 (0.31) logMAR significantly ($P<0.001$). BCVA and AL didn't change significantly after 3mo. All Sphere, cylinder and spherical equivalent (SE) were improved significantly ($P<0.001$). On the other hand, keratometry 1 (K1) and keratometry 2 (K2) decreased significantly. It was a considerable change in SRK/Ⅱ ($P<0.001$), Hoffer Q ($P<0.001$) and Holladay Ⅰ ($P<0.001$) after 3-month's follow-up. Among this formula SRK/II had the lowest change.

• CONCLUSION: In addition to improvement in visual, refractive, and keratometry outcomes after Keraring implantation, there was a significantly changes in IOL calculation formulas values. However, ICRS procedure doesn't interfere considerably AL in eyes, but it seems reduced keratometric values lead to IOL power calculations more accurately and all formulas suggested same IOL power.

• KEYWORDS: intraocular lens; intracorneal ring; keratoconus

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INTRODUCTION

Keratoconus can be defined as a non-inflammatory and bilateral eye disease, starting in springtime, with a progressive loss of corneal thickness and making its surface conical, leading to the loss of sight, visual discomfort and severe refractive errors such as myopia and astigmatism[1-2]. The incidence of keratoconus has been reported between 0.76% to 3.3% in Iran that is much higher than the global average and western countries[3-4]. Due to its impacts on the quality of life and people's eyesight, various but challenging methods are always used to diagnose and treat disease[5-6]. For example, contact lenses can be used to treat and crosslink to prevent the progress in keratoconus early cases and corneal transplant is mentioned as the final treatment in the later stages[7-9]. The use of intraocular rings to correct mild myopia was raised in the treatment of patients with keratoconus by Coughlin in 2000[10]. These rings reconstruct the anterior and posterior corneal surface and thereby smooth its surface with arc-shortening effect mechanism[11-13]. The other surgical procedures to treat keratoconus, such as radial keratectomy and keratotomy photorefractive, are not popular due to the high cost, the lack of foresight and successful sustainability. In comparison to other surgical methods, ring implantation has a greater stability and fewer side effects up to 2%[7-8,14-16]. Vision improvement can be another benefit of intraocular rings which has improved refractive errors and keratometry. In most studies ring implantation led to improvement of vision parameters such as best corrected visual acuity (BCVA), uncorrected visual acuity (UCVA) and keratometry[17-20]. One of the new rings used in surgical procedures is Keraring (ICR; Mediphacos, Minas Gerais, Brazil), which is made of polymethyl methacrylate (PMMA). The ring is designed specifically for nipple-type keratoconus, which can significantly reduce the progression of the disease[21].

Some formulas including SRK/Ⅱ, SRK/T, Hoffer Q and Holladay Ⅰ have been always used in the last three decades for the measurement of intraocular lens power for cataract surgery, whose success depends heavily on biometric measures such as axial length (AL), corneal power and anterior chamber diameter[22-24]. Regarding the biometric changes made after ring implantation, it is necessary to study the accuracy and success of the formulas for determining future intraocular lens surgery. The main aim of this study was to assess and compare the vision and biometry findings before surgery and three months after ring implantation in keratoconus patients. Based on our findings, no study has been conducted so far to compare the power of the lens after ring implantation surgery in patients with keratoconus.

SUBJECTS AND METHODS

This study was conducted as cohort survey on 19 eyes of 18 patients, including 15 males and 3 females with an age range of 21-48. All stages of the study were performed by the scientific board of Bina Eye Hospital Research Center, Tehran, Iran, in compliance with Helsinki treaty. Parameters including keratometry, UCVA, BCVA and manifest refraction were examined before and after lens implantation surgery. Lens power measured by IOL master 500 (Carl Zeiss Meditec) instrument. Visual acuity was measured based on Snellen's test and then converted to logMAR for analysis.

Surgery All surgeries were conducted by the same surgeon (Jadidi K) under local anesthesia with tetracaine and for the correct implantation of intraocular rings; all procedures were done in a general operating room using surgical microscope (OMS-800 Standard TOPCON Corporation, Japan).

The surgical procedure was performed based on our previous study[25] briefly pocket was created within the corneal stroma using a Pocket Maker microkeratome (Dioptex GmbH) when correct position of the blade was determined, the microvibrating diamond blade was set at 300 μm of the measured corneal thickness and a single 2 mm radial incision was made at the steepest meridian. Then, the applicator was fixated to the eye by the suction ring. The suction ring was removed from the eye after creating a closed intrastromal pocket of 8.5 mm diameter and 300 μm depth through the small incision tunnel. The appropriate Keraring 355° segment thickness was selected and then implanted in the eye according to the new nomogram designed based on the author's experiences. The centration of the implant was adjusted using keratoscope. Silicone hydrogel bandage contact lens was placed on the cornea after surgery and then, betamethasone (Sina Darou, Iran) and chloramphenicol (Sina Darou, Iran) each 4 times a day and artificial tear eye drop (Artelac, Bausch & Lomb, France) 6 times a day were prescribed for patients. Chloramphenicol eye drop was administered for a week and then stopped and betamethasone eye drop began totipper after 4-6wk. All patients were revisited one month and three months after surgery.

Statistical Analysis In this study, all visual acuity measurements were converted from the Snellen notation to logMAR. All continuous variables were expressed as mean (SD) and range. Paired t-test was used to assess the significance of differences for continuous variables between pre- and 3 month-postoperative refractive and visual outcomes. The threshold of statistical significance was $P<0.05$.

RESULTS

Nineteen eyes of 18 patients (15 males and 3 females) with the mean age of 29.58±0.6 underwent surgical implantation of Keraring 355°. All patients were evaluated 3mo after implantation of the ring and included in the study. The average preoperative UCVA was 0.84 (0.35) with a range of 0.2-1.3 logMAR which was significantly improved after 3mo and reached 0.43 (0.31) with a range of 0.1-1.0 logMAR ($P<0.001$) (around 5 lines improvement). The preoperative BCVA was 0.32 (0.14) with a range of 0.1-0.5 logMAR which reached 0.23 (0.15) with a range of 0.1 logMAR

Table 1 Comparison of visual and refractive outcomes between preoperative and 3mo postoperative examination

Parameters	Preoperative	3mo postoperative examination	*P*
UCVA (logMAR)			
Mean (SD)	0.84 (0.35)	0.43 (0.31)	0.001
Range	0.2, 1.3	0.1, 1.0	
BCVA (logMAR)			
Mean (SD)	0.32 (0.14)	0.23 (0.15)	0.056
Range	0.1, 0.5	0.1, 0.5	
Sphere (D)			
Mean (SD)	-2.40 (1.18)	-0.2 (2.89)	0.005
Range	-5.5, -0.75	-6.00, +5.00	
Cylinder (D)			
Mean (SD)	-4.47 (1.24)	-2.08 (1.53)	<0.001
Range	-6.75, -2.00	-5.00, +0.75	
Spherical equivalent (D)			
Mean (SD)	-4.64 (1.53)	-1.24 (3.10)	<0.001
Range	-8.88, -2.75	-8.00, +3.75	

SD: Standard deviation; D: Diopter; Significances are based on paired *t*-test.

Table 2 Comparison of biometry outcomes and IOL power calculation formulas between preoperative and 3mo postoperative examination

Parameters	Preoperative	3mo postoperative examination	*P*
AL (mm)			
Mean (SD)	24.10 (0.87)	24.09 (0.86)	0.331
Range	23.00, 26.00	23.00, 26.00	
K1 (D)			
Mean (SD)	45.58 (1.77)	41.91 (3.79)	0.002
Range	42.00, 58.00	35.00, 49.00	
K2 (D)			
Mean (SD)	51.06 (2.01)	44.36 (3.18)	0.003
Range	47.00, 55.24	40.00, 51.00	
SRK/T (D)			
Mean (SD)	14.26 (2.74)	19.47 (4.11)	<0.001
Range	7.50, 19.50	14.00, 27.00	
SRK/Ⅱ (D)			
Mean (SD)	14.76 (2.40)	19.42 (3.73)	<0.001
Range	10.00, 19.50	14.00, 26.00	
Hoffer Q (D)			
Mean (SD)	12.50 (3.16)	19.34 (5.20)	<0.001
Range	5.50, 19.00	10.50, 28.50	
Holladay Ⅰ (D)			
Mean (SD)	13.11 (3.08)	19.47 (4.74)	<0.001
Range	6.00, 19.00	11.00, 27.50	

SD: Standard deviation; D: Diopter; Significances are based on Paired *t*-test.

postoperatively (1 line improvement). This improvement was not significant ($P<0.056$). Other parameters including sphere ($P<0.005$), cylinder ($P<0.001$) and spherical equivalent (SE) ($P<0.001$) were significantly improved (Table 1).

After the implantation of the ring, AL did not differ significantly with the preoperative one ($P<0.331$). A significant decrease was observed in keratometry parameters. Preoperative average of K1 was 45.58±1.77 D (with a range of 42.00-58.00 D), which was significantly improved to 41.91±3.79 D (with a range of 35.00-49.00 D) ($P<0.002$). The mean K2 in pre-operative examination was 51.06±2.01 D (with a range of 47.00-55.24 D) and significantly reached to 44.36±3.18 D with a range of 40.00-51.00 D. It was observed that significant changes are seen in the IOL power calculated by different formulas such as SRK/Ⅱ ($P<0.001$), SRK/T ($P<0.001$), Hoffer Q ($P<0.001$), Holladay Ⅰ ($P<0.001$) which can be seen in Table 2.

It is worth mentioning that no side effect was found at the end of the first 3mo period.

DISCUSSION

Intracorneal rings always referred as one of the useful tools to improve the corneal disorder and improve visual acuity. Several studies have been published about efficacy and safety of rings in patients with keratoconus[9, 11-12, 26-28]. In the present study, we compared refractive and biometric characteristics and IOL power calculation formulas before and after Keraring 355° implantation in 18 patients with keratoconus.

In our study, although the UCVA improved significantly after 3mo, but BCVA improvement was not significant. In a study by Piñero *et al*[27], UCVA significantly improved within 3mo after surgery, while similar to our results, no significant improvement was observed in BCVA.

According to previous studies, in 95% of patients, UCVA improved after operation and this factor remained constant over the years[29]. Of course, it is important to note that the most patients selected for ring implantation suffer from corneal thickness reduction in its center and so UCVA also improved after insertion of the ring due to corneal flattening[27].

Different amounts of postoperative BCVA improvement have been always reported in different studies. Of course, it largely depends on its preoperative amount and the severity of keratoconus[7, 12, 18, 27]. It seems that the successful implantation of rings and improvement in UCVA is very noticeable in our study.

It can be noted that all main factors including sphere, cylinder and SE improved 3mo after surgery. Many studies have also reported findings similar to ours[30-32]. For example, in a study by Kymionis *et al*[13], SE and cylinder reduced 3.1 D and 2 D, respectively. In another report, it was observed that SE reduced significantly in all grades of keratoconus, especially in patients with severe keratoconus (grades 3 and 4)[8]. The flattening of the cornea after Keraring implantation can be considered as one of the possible reasons.

In the present study, it showed that keratometry values reduced significantly after ring implantation. Because the ring flattens the cornea surface *via* corneal remodeling it is suggested that K1 is the best and the most sensitive factor for investigation of eye treatment after intracorneal ring implantation. Improvement is largely related to the depth of insertion and using femtosecond leads to better results[11]. In some studies, a significant decrease has been reported in K1 and K2. Haddad *et al*[31] showed that K1 and K2 decreased 2 D and 3 D in 6mo follow up. A significant postoperative decrease in K1 was reported in another study conducted by Kymionis *et al*[13], that proved the effectiveness of rings on improvement of corneal thickness.

One of the important results of our study is significant changes in the values of formulas SRK/T, SRK/Ⅱ, Holladay Ⅰ and Hoffer Q. These formulas are used for measuring intraocular lens power in cataract surgery. The ability of these formulas to predict the lens power is different[33-35]. Only AL was being used in the first generation of the formulas to predict the location of the IOL and gradually with the development of the next generations in formulas such as (Holladay Ⅰ, SRK/T and Hoffer Q), other parameters such as corneal curvature are used to predict the effective lens position. Followed by the improvement in the 4th generation of formulas such as Holladay Ⅱ some parameters including corneal diameter and thickness along with refraction and patient's age are used to better predict the final location and IOL power[36]. According to our observations, lens power calculated by these formulas is different before ring insertion and this difference makes it difficult to select the best power lens in patients with keratoconus. However, results from the each formula for estimating the intraocular lens power depends on the AL as well. For example, Holladay Ⅰ is more successful for eyes with long AL (24.5 mm to 26.0 mm), and SRK/T for much longer ones (>26.0 mm). It is while that Hoffer Q is effective for the eyes with AL less than 22 mm. In comparison with our results it is observed that despite the AL average value 24 mm in eyes operated in our study, all formulas have changed considerably. Since AL had no significant difference before and after insertion of the ring, the calculated postoperative lens power increased due to the reduction in keratometry values and all formulas calculated lens power almost the same. Likewise, keratoconus induced irregularity, astigmatism and higher corneal curvature which lead to inaccurate results and mistaken calculation. Therefore, impaired corneal structure yield to discrepancy of normal population parameters and increasing calculating errors. It seems, ring implementation on keratoconus corneas modified irregularity to nearly regularity which could be proven by decreasing keretometry indexes. So, results of IOL power calculation on ring implemented eyes categorize in normal population range. Other studies have been shown if the intraocular ring was implanted prior IOL insertion, the power of intraocular lens was calculated more accurately. Because of improving the shape of the cornea, it leads to estimation of the corneal power and therefore prediction of the lens location is performed more accurately[37]. Our study confirms these findings too.

In cataract surgery, more attention is needed to accurately calculate formulas to determine intraocular lens power. Our study is firstly performed to compare formulas used to calculate the lens power such as SRK/T, SRK/Ⅱ, Hoffer Q and Holladay Ⅰ, refractive and keratometry values before and after Keraring 355° implantation. Refractive and keratometry values are improved significantly and calculated IOL power by all formulas was increased too. In brief, Keraring implantation could improve corneal stability and consequently all formulas proposed same IOL power, so decision about patients' lens power was performed with more decisiveness. It is suggested that future studies with a large number of patients, long follow-up time, comparing the ring types and other formulas such as Holladay Ⅱ to be conducted.

REFERENCES

1 Kanellopoulos AJ, Asimellis G. Revisiting keratoconus diagnosis and progression classification based on evaluation of corneal asymmetry

indices, derived from Scheimpflug imaging in keratoconic and suspect cases. *Clin Ophthalmol* 2013;7:1539-1548

2 Brautaset RL, Nilsson M, Miller WL, Leach NE, Tukler JH, Bergmanson JP. Central and peripheral corneal thinning in keratoconus. *Cornea* 2013;32(3):257-261

3 Hashemi H, Khabazkhoob M, Fotouhi A. Topographic keratoconus is not rare in an Iranian population: The Tehran eye study. *Ophthalmic Epidemiol* 2013;20(6):385-391

4 Hashemi H, Beiranvand A, Khabazkhoob M, Asgari S, Emamian MH, Shariati M, Fotouhi A. Prevalence of keratoconus in a population-based study in Shahroud. *Cornea* 2013;32(11):1441-1445

5 Kymes SM, Walline JJ, Zadnik K, Sterling J, Gordon MO, Group CLEoKS. Changes in the quality-of-life of people with keratoconus. *Am J Ophthalmol* 2008;145(4):611-617

6 Yokoi T, Moriyama M, Hayashi K, Shimada N, Tomita M, Yamamoto N, Nishikawa T, Ohno - Matsui K. Predictive factors for comorbid psychiatric disorders and their impact on vision-related quality of life in patients with high myopia. *Interophthalmol* 2014;34(2):171-183

7 Alió JL, Shabayek MH, Artola A. Intracorneal ring segments for keratoconus correction: long - term follow - up. *J Cataract Refract Surg* 2006;32(6):978-985

8 Vega - Estrada A, Alio JL, Brenner LF, Javaloy J, Puche AB, Barraquer RI, Teus MA, Murta J, Henriques J, Uceda - Montanes A. Outcome analysis of intracorneal ring segments for the treatment of keratoconus based on visual, refractive, and aberrometric impairment. *Am J Ophthalmol* 2013;155(3):575-584. el

9 Kanellopoulos AJ, Lawrence HP, Perry HD, Donnenfeld ED. Modified intracorneal ring segment implantations (INTACS) for the management of moderate to advanced keratoconus: efficacy and complications. *Cornea* 2006;25(1):29-33

10 Colin J, Cochener B, Savary G, Malet F, Holmes - Higgin D. INTACS inserts for treating keratoconus: one - year results. *Ophthalmology* 2001;108(8):1409-1414

11 Coskunseven E, Kymionis GD, Tsiklis NS, Atun S, Arslan E, Jankov MR, Pallkaris IG. One-year results of intrastromal corneal ring segment implantation (KeraRing) using femtosecond laser in patients with keratoconus. *Am J Ophthalmol* 2008;145(5):775-779

12 Israel M, Yousif MO, Osman NA, Nashed M, Abdelfattah NS. Keratoconus correction using a new model of intrastromal corneal ring segments. *J Cataract Refract Surg* 2016;42(3):444-454

13 Kymionis GD, Siganos CS, Tsiklis NS, Anastasakis A, Yoo SH, Pallikaris AI, Astyrakakis N, Pallikaris IG. Long - term follow - up of Intacs in keratoconus. *Am J Ophthalmol* 2007;143(2):236-244

14 Lai MM, Tang M, Andrade EM, Li Y, Khurana RN, Song JC, Huang D. Optical coherence tomography to assess intrastromal corneal ring segment depth in keratoconic eyes. *J Cataract Refract Surg* 2006;32(11):1860-1865

15 Shalchi Z, O'Brart DP, McDonald RJ, Patel P, Archer TJ, Marshall J. Eighteen-year follow-up of excimer laser photorefractive keratectomy. *J Cataract Refract Surg* 2015;41(1):23-32

16 Spadea L, Cantera E, Cortes M, Conocchia NE, Stewart CW. Corneal ectasia after myopic laser in situ keratomileusis: a long - term study. *Clin Ophthalmol* 2012;6(1):1801-1813

17 Güell JL. Are intracorneal rings still useful in refractive surgery? *Curr Opin Ophthalmol* 2005;16(4):260-265

18 Wachler BSB, Chandra NS, Chou B, Korn TS, Nepomuceno R, Christie JP. Intacs for keratoconus. *Ophthalmol* 2003; 110 (5): 1031-1040

19 Rabinowitz YS. Intacs for keratoconus. *Int Ophthalmol Clin* 2006;46(3):91-103

20 Menezes C, Rodrigues P, Resende RA, Lemos JA, Coelho P, Vieira BC, Serino J, Gonçalves R, Tenedório P. Keratometric index variation in keratoconic eyes before and after Intacs - SK implantation. *Rev Soci Port Oftalmologia* 2015;39(1):17-22

21 Jadidi K, Mosavi SA, Nejat F, Naderi M, Janani L, Serahati S. Intrastromal corneal ring segment implantation (Keraring 355°) in patients with central keratoconus: 6 - month follow - up. *J Ophthalmol* 2015:916385

22 Olsen T. Calculation of intraocular lens power: a review. *Acta Ophthalmol* 2007;85(5):472-485

23 Seitz B, Langenbucher A. Intraocular lens power calculation in eyes after corneal refractive surgery. *J Refract Surg* 2000;16(3):349-361

24 Awwad ST, Manasseh C, Bowman RW, Cavanagh HD, Verity S, Mootha V, McCullty JP. Intraocular lens power calculation after myopic laser in situ keratomileusis: estimating the corneal refractive power. *J Cataract Refract Surg* 2008;34(7):1070-1076

25 Jadidi K, Mosavi SA, Nejat F, Alishiri A. Complications of intrastromal corneal ring implantation (Keraring 355°) using a femtosecond laser for channel creation. *Inter J KeratoEcta Corn Dis* 2014;3(2):53-56

26 Coskunseven E, Jankov MR, Hafezi F, Atun S, Arslan E, Kymionis GD. Effect of treatment sequence in combined intrastromal corneal rings and corneal collagen crosslinking for keratoconus. *J Cataract Refract Surg* 2009;35(12):2084-2091

27 Piñero DP, Alio JL, El Kady B, Coskunseven E, Morbelli H, Uceda-Montanes A, Malolonado MJ, Cuevas D, Pascual I. Refractive and aberrometric outcomes of intracorneal ring segments for keratoconus: mechanical versus femtosecond - assisted procedures. *Ophthalmol* 2009; 116(9):1675-1687

28 Kubaloglu A, Sari ES, Cinar Y, Koytak A, Kurnaz E, Özertürk Y. Intrastromal corneal ring segment implantation for the treatment of keratoconus. *Cornea* 2011;30(1):11-17

29 Alfonso JF, Lisa C, Merayo-Lloves J, Cueto LF-V, Montés-Micó R. Intrastromal corneal ring segment implantation in paracentral keratoconus with coincident topographic and coma axis. *J Cataract Refract Surg* 2012;38(9):1576-1582

30 Kwitko S, Severo NS. Ferrara intracorneal ring segments for keratoconus. *J Cataract Refract Surg* 2004;30(4):812-820

31 Haddad W, Fadlallah A, Dirani A, El Rami H, Fahd D, Khanafer D, Fahed S. Comparison of 2 types of intrastromal corneal ring segments for keratoconus. *J Cataract Refract Surg* 2012;38(7):1214-1221

32 Alió JL, Artola A, Hassanein A, Haroun H, Galal A. One or 2 Intacs segments for the correction of keratoconus. *J Cataract Refract Surg* 2005;31(5):943-953

33 Hoffer KJ. Clinical results using the Holladay Ⅱ intraocular lens power formula. *J Cataract Refract Surg* 2000;26(8):1233-1237

34 Wang L, Booth MA, Koch DD. Comparison of intraocular lens power calculation methods in eyes that have undergone LASIK. *Ophthalmol* 2004;111(10):1825-1831

35 Aristodemou P, Cartwright NEK, Sparrow JM, Johnston RL. Formula choice: Hoffer Q, Holladay Ⅰ, or SRK/T and refractive outcomes in 8108 eyes after cataract surgery with biometry by partial coherence interferometry. *J Cataract Refract Surg* 2011;37(1):63-71

36 Narváez J, Zimmerman G, Stulting RD, Chang DH. Accuracy of intraocular lens power prediction using the Hoffer Q, Holladay Ⅰ, Holladay Ⅱ, and SRK/T formulas. *J Cataract Refract Surg* 2006; 32(12):2050-2053

37 Madrid-Costa D, Montés-Micó R. Intrastromal corneal ring segment and intraocular lens implantation in patients with keratoconus and cataract. *J Emmetropia* 2012;3:193-200