·Clinical Research·

Rigid contact lens fitting based on keratometry readings in keratoconus patients: predicting formula

Mohammad Taher Rajabi [1], Zahra Mohajernezhad-fard [1], Seyede Khojaste Naseri [2], Fahimeh Jafari [2], Askar Doostdar [2], Parviz Zarrinbakhsh [3], Mohammad Bagher Rajabi [1], Sedigheh Kohansal [1]

[1]Department of Ophthalmology, Farabi Eye Hospital, Tehran University of Medical Sciences, Tehran, Iran
[2]Department of Optometry, Tehran University of Medical Sciences, Tehran, Iran
[3]Zarrinbakhsh Clinic, Tehran University of Medical Sciences, Tehran, Iran
Correspondence to: Mohammad Taher Rajabi. Department of Ophthalmology, Farabi Eye Hospital, Tehran University of Medical Sciences, Tehran, Iran.mt_rajabi@yahoo.com
Received:2011-01-07 Accepted:2011-08-15

Abstract

• AIM: To find a simple mathematical correlation between the lens base curve (BC) and keratometry findings (krf).

• METHODS: This retrospective study included 400 keratoconic eyes (350 patients) previously fit with rigid contact lenses at an academic eye center over a five year period. The patients were classified into five groups based on the keratometry findings (krf<7, krf:7-8, krf>8, krf-krs (difference between two keratometry; flat and steep)= 0.3-0.6, krf-krs >0.6mm as groups 1 to 5, respectively. Multivariate linear regression and Munro's correlation coefficient were employed to defer the formulas.

• RESULTS: A linear correlation could be found in all groups except for patients in group 3. For group 1, BC=0.211×krf+ 5.904. For group 2, BC=0.456×krf+4.160. For group 4,BC= 0.321×krf+5.219. For group 5, BC=0.337×krf+ 5.090.

• CONCLUSION: The development of new formulas for RGP fitting enables ophthalmologists to work with confidence and prevents unnecessary and frequent lens trials. The customary lens fitting methods are needed to be replaced by new formulas, which help to save time and costs.

• KEYWORDS: keratoconus; keratometry; lens fitting

DOI:10.3980/j.issn.2222-3959.2011.05.13

Rajabi MT, Mohajernezhad-fard Z, Naseri SK, Jafari F, Doostdar A, Zarrinbakhsh P, Rajabi MB, Kohansal S. Rigid contact lens fitting based on keratometry readings in keratoconus patients: predicting formula. *Int J Ophthalmol* 2011;4(5):525-528

INTRODUCTION

Keratoconus is the abnormal, progressive, bilateral, and asymmetrical thinning of the centrum of the cornea[1]. The resultant corneal ectasia, protrusion and disruption of the optics of the cornea occur as a result of pressurized fluid within the eye[1,2]. The disease usually starts at childhood and adolescence, deteriorates over the next 7-8 years and reaches a plateau afterwards. In the early stages, most patients are asymptomatic, except for frequent changes in their eye sight, which represents as myopia, regular or irregular and moderate or severe astigmatism. In most cases, the disease is suspected when eye glasses are unable to correct the vision or when rapid changes in astigmatism develop.

Corneal topographic map reveals regular or irregular increments in corneal power and pachymetry shows gradual decrease in corneal thickness. When the disease is mild, wearing eye glasses might be enough and sometimes the patients experience better corrected vision in comparison with wearing contact lenses; however the latter (hard contact lenses) are regarded as the mainstay of treatment in severe myopia and astigmatism. Surgery is reserved for the patients who cannot tolerate contact lenses or those who gain no improvement in their vision.

Rigid contact lenses and especially rigid gas permeable (RGP) lenses are the treatment of choice in advanced disease [3-5]. In these lenses, two or three base curves (BC) are made behind each lens. Although rigid contact lens fitting takes more time and care than hydrogel lenses, they are typically used for the severe stages of the disease[6].

The first and most important factor in the selection of lenses for keratoconic patients is the severity of the disease (mild, moderate or severe). Although keratometry and topography or a combination of the two helps in this selection [7], the variations in the severity of the disease in each patient makes the process of the rigid contact lens fit lengthy and sometimes inaccurate. The ability to more accurately pick the initial rigid lens base curve based on keratometry readings (krf) or corneal topography helps an apprentice fitter to fit the lenses with more confidence. Although the literature lacks to provide such level of confidence for the fitter, there are a few studies to support the idea [8-10]. The development of new formulas, which could be able to estimate the base curve for each patient due to the keratometry reading, not only helps to fit more accurate lenses, but also saves in time and costs.

We planned this study with the main aim to find a mathematical correlation between rigid contact lens base curve and keratometry reading, which enables the less experienced fitter to pick the initial lens with more confidence.

MATERIALS AND METHODS

Patients This retrospective study included 350 keratoconus patients (400 eyes) previously fit with rigid corneal contact lenses (Boston type RGP, ILG CO. Tehran, Iran) over a 5 year period at an academic eye center. Figure 1 shows the fluorescein pattern of three point touch after RGP fit in a patient with keratoconus.

Methods The research was approved by the local institutional review board. The patients' folders were reviewed by an experienced ophthalmologist and the data including patient's age, visual acuity, prefit corneal topography data, keratometry readings and the final best-fit base curve were extracted. Patients with RGP intolerance, ocular surface disorders due to RGP wearing, and visual loss due to corneal pathology were excluded.

The patients were then classified into five groups based on their keratometry reading: krf<7, krf:7-8, krf>8, krf-krs (difference between 2 keratometry flat and steep) =0.3-0.6, krf-krs>0.6mm as groups 1 to 5, respectively. This classification was chosen in this purpose to better classify severe and mild disease. In 2 last group our aim was to find that is there any linear association when the difference between 2 keratometry in less than 0.6 and more.

Multivariate linear regression and Munro's correlation coefficient were employed to defer the formula (s) in an effort to describe the mathematical correlation between the prefit topographic data and the final best-fit base curve.

RESULTS

Group A of patients (krf<7mm) demonstrated a significant correlation between BC and keratometry reading (r =0.296, P<0.001). Munro's correlation coefficient table showed that this correlation should be considered low in power. Also, because of β=0.296 and P<0.001, kr (an independent variable) can predict BC value. With r=0.296, c=5.904 and kr=0.211, the predicting formula would be: BC=0.211 × krf+5.904 (Table 1). There was a statistically significant correlation between BC and keratometry reading in Group B of patients (krf=7-8mm) (r=0.468, P<0.001), which was considered as of low power correlation in Munro's

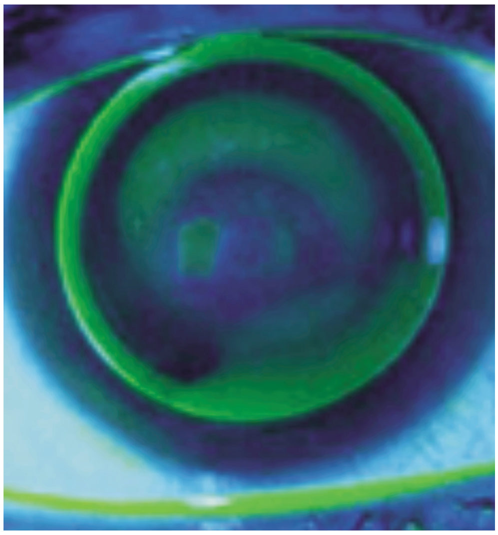

Figure 1 Three point touch pattern in a patient with Keratoconus

correlation coefficient table. Because of β= 0.468 and P< 0.001, the independent variable (kr) can predict BC value in these patients, too. With r=0.468, c=4.16 and kr= 0.465, the predicting formula for this group would be as: BC= 0.465 × krf+4.16 (Table 1).

No statistically significant correlation was found between BC and keratometry reading for the group 3 of patients (krf>8mm) (r=0.77, P<0.15) and Munro's table considered this correlation high. Because of β=0.77 and P<0.15, which demonstrates a meaningless value, no formula could be suggested for this group. A statistically significant correlation was found between BC and a difference of 0.3-0.6mm between the two radial curves of the cornea in group 4 of patients, which was considered as of medium power in Monro's table. Because of β=0.612 and P<0.001, kr could predict BC as an independent factor. Due to r= 0.612,c=5.219 and kr=0.321, BC could be estimated through the following formula: BC=0.321×krf+5.219 (Table 2).

Group 5 of patients revealed a significant correlation between the base curve of RGP lenses and a difference of more than 0.6mm in two radial curves of the cornea. This correlation was regarded as of medium strength in Monro's table. Because of β=0.528 and P<0.001, kr is able to predict BC.Considering r=0.528, c=5.090 and kr=0.337,the suggested formula would be as follows:BC=0.337×krf+5.090(Table 2).

DISCUSSION

Our study shows that a linear correlation could predict the initial rigid contact lens base curve in keratoconic patients with an acceptable accuracy, which leads to achieving a well-fit rigid lens in a shorter period of time.

Keratoconus is a progressive disease due to the alterations in central and paracentral corneal thickness. Eye glasses are only effective during the first stages of the disease, while

Table 1 Analysis of regression correlation between BC and krf<7mm

Kr	Variable	Average±SD	Pierson correlation	*P*	*F*	*P*	Regression coefficient				
							R	C	Kr coefficient	β	*P*
<7mm	BC	7.283±0.261	0.296	<0.001	18.4	<0.001	0.296	5.904	0.211	0.296	<0.001
	Krf	6.535±0.366									
	Predicting formula based on krf	BC=0.211 ×krf + 5.904									
	SEM	± 0.47									
7-8mm	BC	7.851±0.229	0.468	<0.001	54.64	<0.001	0.468	4.160	0.465	0.296	<0.001
	Krf	7.355±0. 231									
	Predicting formula based on krf	BC=0.465 ×krf + 4.16									
	SEM	± 0.40									

Table 2 Analysis of regression correlation between BC and krf in keratoconus patients with a difference of 0.3-0.6 mm between two radial curves of the cornea

Differnce	Variable	Average±SD	Pierson correlation	*P*	*F*	*P*	Regression coefficient				
							R	C	Kr coefficient	β	*P*
0.3-0.6mm	BC	7.440±0.280	0.612	<0.001	151.24	<0.001	0.612	5.219	0.321	0.612	<0.001
	Krf	6.535±0.366									
	Predicting formula based on krf	BC=0.321 ×krf + 5.219									
	SEM	±0.43									
>0.6 mm	BC	7.452±0.326	0.528	<0.001	53.75	<0.001	0.528	5.09	0.337	0.528	<0.001
	Krf	6.535±0.366									
	Predicting formula based on krf	BC=0.337 ×krf +5.090									
	SEM	±0.54									

contact lenses are necessary during the advanced stages. Surgery is considered for the patients who cannot tolerate the lenses or when no suitable correction is made applying contact lenses. The application of soft contact lenses has two main limitations in keratoconic patients. First, in these patients the astigmatism is not equal in two meridians and soft lenses are unable to correct this type of astigmatism. Second, soft lenses need to be made thick enough to correct an irregular or high astigmatism and the resultant corneal edema is a common problem. Rigid contact lenses are free from these limitations and are commonly used in keratoconic patients.

The accurate choose of rigid lens base curve with the help of the data obtained from keratometry or corneal topography is intriguing, however the literature does not provide enough supportive evidences. The selection of a base curve equal to the flatter keratometry reading [10] or the flat keratometry measure [9] in the initial studies in 1980's lacked to provide any supportive reference or rational related to these choices. In a study by Lin *et al* [6], the authors found that the patients' kr has the best correlation with the selected lens base curve and this correlation was stronger when kr becomes flatter. The authors proposed the following formula to calculate the base curve for these patients: BC=4.742+0.364×krf.

In that study, the formula was correct when the average of the flatter kr was 7.4mm, however for any change of 0.3mm in kr above or below the average, BC needed to be changed 0.1mm, too. The authors concluded that BC becomes flatter than krf when krf<7.4, while it becomes steeper than krf in values more than 7.4mm. The proposed single formula in Lin *et al* study [6] makes rigid contact lens fitting simple and easy; however it seems that other formulas are also necessary due to the variations of kr in different stages of the disease. In another study, Edrington *et al* [11], tried to fit keratoconic eyes with the first lens which showed apical fluorescine aggregation (FDACL). The authors found that in mild keratoconus [steeper meridian keratometry <45 diopter (D)] lenses were fitted 1.18 D flatter than FDACL (SD=1.84 diopter). This figure was found to be 2.38D and 4.01D flatter than FDACL for moderate (steeper meridian keratometry= 45-52D) and severe (steeper meridian keratometry >52D) kertoconic eyes, retrospectively. On average, contact lenses were fitted 2.86D flatter than FDACL (11). Because keratoconic patients find flat rigid contact lens fitting more acceptable and tolerable, it is not suitable to select steeper meridian for the lens trial and it is more acceptable to initially choose flatter meridian for these patients. In a study by Zednik *et al*[12], the authors claim that no specific formula could be used to fit rigid contact lenses in keratoconic patients, however lens base curve is closer to the flattest keratometry findings during the initial stages of the disease and the more advanced the disease, the steeper the lens base curve. They concluded that the changes in lens base curve develops later than corneal base curve and in advanced disease the lens base curve should be chosen flatter than the flattest curve found by keratometry.

The severity of keratoconus is different in patients and this confronts the ophthalmologists with a wide spectrum of corneal radial curves in different patients. Therefore choosing only one base curve for lens trial in our patients and then choosing lens power as the initial fit will end up in choosing steeper or flatter lens for a given patient, which needs various changes to fit the lens. It appears that it is more appropriate to choose different base curves for different stages of keratoconus and then determine lens power after fitting by over-refraction. In this study, we found krf to be a powerful predictor of BC in different groups of keratoconus patients. The strength of the present study lies in classifying the patients into five groups and separately analyzing the results in each group, which enabled us to avoid the possible biases and strengthen the results. The main drawback of this study is its inability to compare correlation between left and right eyes, because independent observations would be violated if left and right eyes are correlated in the dependant variable. This issue has been discussed in the literature[13,14].

In summary, although rigid gas-permeable contact lenses play a decisive role in the treatment of keratoconic patients, the method of lens fitting play a more important role to increase the chance of successful treatment. Random fitting and multiple lens trials are not easy and safe enough for these patients. So, the development of new formulas to fit the best lens base curve based on patients' keratometry readings or prefit corneal topography seems necessary to overcome the above mentioned limitations in these patients. Finding such formulas would allow ophthalmologists to fit rigid contact lenses with more assurance and prevents unnecessary and frequent lens trials.The final consequences will be saving in costs and time, which benefits both the patients and the ophthalmologist. The customary lens fitting methods are suggested to be replaced by the formulas found in this study and the similar studies.

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