Initial Power of Rigid Gas Permeable Contact Lenses in Patients with Keratoconus

Fereshteh Birjandi[1,2], Hadi Ostadimoghaddam[1,2], Abbasali Yekta[1,2], Monireh Mahjoob[3]

[1]Department of Optometry, School of Paramedical Sciences, Mashhad University of Medical Sciences, Mashhad, Iran, [2]Refractive Errors Research Center, Mashhad University of Medical Sciences, Mashhad, Iran, [3]Health Promotion Research Center, Zahedan University of Medical Sciences, Zahedan, Iran

Abstract

Purpose: To simplify the fitting process, this study was designed to predict the initial power of contact lenses using the regression model based on manual Javal keratometry data and refractive errors.

Methods: In this retrospective study, 121 eyes of 69 patients with keratoconus (KCN) were fitted with a specific trial set of rigid gas permeable contact lenses based on the standard criterion of "three-point touch" over a 7-year period. Power of the cornea was measured using Javal keratometer. Refractive errors and over refraction of patients were diagnosed using Topcon autorefractometer (RM-A2000) and confirmed by Heine beta 2000 retinoscope.

Results: The results of multiple linear regression showed the following equation: power of contact lens = −14.368 (constant of the final multiple regression model), +0.475 (spherical refraction), and +0.275 (flatter corneal power).

Conclusions: The results of this study revealed that lens power has a significant relationship with the power of the flat corneal meridian and spherical refractive error in KCN patients. The obtained regression model can be used to shorten patients' chair time and optometric examination for predicting the power of contact lens.

Keywords: Javal keratometry, Keratoconus, Rigid gas permeable contact lens

Address for correspondence: Monireh Mahjoob, Health Promotion Research Center, Zahedan University of Medical Sciences, Zahedan, Iran.
E-mail: mahjoob_opt@yahoo.com
Submitted: 17-Jan-2021; **Revised:** 25-Apr-2021; **Accepted:** 30-Apr-2021; **Published:** 06-Jan-2022

Introduction

Keratoconus (KCN) is a noninflammatory eye disease in which the cornea becomes thin and distorted. In this disease, due to increased irregular astigmatism and high myopia, patients' vision declines quantitatively and qualitatively.[1] There are several options for the management of KCN such as spectacles, contact lenses, implantation of intracorneal segment rings, phakic intraocular lenses (IOL), corneal collagen cross-linking, and keratoplasty.[2] In the early stages of KCN, spectacles can improve patients' vision. However, as the disease progresses, rigid gas permeable (RGP) contact lenses play an important role in patients' refractive correction.[3]

Contact lenses fitting for patients with KCN are challenging[3] and require several diagnostic RGP fitting sets. Although corneal topography plays a substantial role in monitoring of KCN and determining the parameters required to administer contact lenses,[4,5] one must consider the cost and application of routine instruments when prescribing lenses.[6,7] Hand-held keratometer is commonly used in contact lens clinics. They are less expensive and available to people living in more disadvantaged areas.[7,8] Furthermore, it has been found that among five corneal topography devices including Pentacam, EyeSys, Orbscan, IOL Master, and Javal keratometer, the reproducibility and accuracy of Javal keratometer following Pentacam were greater than those of the other devices.[9]

Access this article online
Quick Response Code:
Website: www.jcurrophthalmol.org
DOI: 10.4103/joco.joco_23_21

How to cite this article: Birjandi F, Ostadimoghaddam H, Yekta A, Mahjoob M. Initial power of rigid gas permeable contact lenses in patients with keratoconus. J Curr Ophthalmol 2021;33:413-6.

The power of contact lenses is usually calculated based on the patients' refractive error and over-refraction while considering the vertex distance. Various studies have confirmed that refractive errors are related to the axial length of the eye and corneal power.[10-13] One of important causes of contact lenses reorder in KCN patients is the changes in contact lens power, but with an optimal over-refraction along with other parameters of contact lens fit, the chance of a successful fit could increase from 64% to 84%.[14] While over-refraction in patients with KCN is difficult due to the initial discomfort with RGP lenses and the presence of an irregular tear film between the lens and the cornea,[14] it is helpful and time-saving to use regression models to estimate the initial lens power in the fitting process of KCN patients, especially those who do not have necessary cooperation.

To facilitate the fitting process in terms of patient comfort and time reduction, predicting the initial parameters (such as base curve, diameter, and lens power) is essential. One way to achieve this purpose is to take advantage of those models and formulas proposed by researchers and lens manufacturers.[7] Due to the important role of determining the accurate power of contact lens to enhance vision in KCN patients, the aim of this study was to find an appropriate regression model for predicting the initial power of corneal RGP contact lenses. This was done using routine measuring instruments and considering patients' corneal power and refractive errors. It is hoped that the results of this study will be effective in facilitating the process of contact lens fitting, as well as directing future research.

Methods

This retrospective study was performed on 121 eyes of 69 patients with KCN who referred to a private optometry office between 2005 and 2011. This study followed the Declaration of Helsinki and was approved by the Vice Chancellor for Information Technology of Mashhad University of Medical Sciences with the ethical code IR.MUMS.REC.1396.166.

The KCN diagnosis for all patients was based on the results of slit-lamp examination, corneal topographic, and pachymetric assessments and the definitive opinion of an ophthalmologist. The diagnosis criteria were central corneal power above 47.2 diopters, inferior–superior corneal power asymmetry above 1.4 diopters, and a slope above 21° on asymmetric astigmatic axes. Having non-KCN corneal pathologies such as trauma, contact lens intolerance, ocular abnormality because of wearing contact lens, lack of accurate keratometry because of deviation and deformation of mires, and corneal edema before fitting were considered exclusion criteria.

Before contact lens fitting, keratometry was performed using Javal Keratometer to determine corneal power and corneal astigmatism. Refractive errors of patients were diagnosed using Topcon autorefractometer (RM-A2000) and confirmed by Heine beta 2000 retinoscope. Subjective refraction was also performed for the best vision, which was recorded using the E chart at a distance of 6 m.

A trial set of multicurved corneal RGP contact lenses with aspherical edge design (Wohlk type RGP, Conflex KE, Germany) was used for all patients. The trial lens set included a number of lenses with the overall diameter and power of 9.50 mm and − 3.00 diopter, respectively, and the base curves ranged from 6.40 to 7.90 mm in 0.1 mm steps. The correct fit of the lenses was performed diagnostically by only one examiner, taking into account all the effective dynamic and static factors that lead to sufficient quantitative and qualitative vision for the patient. The corneal RGP contact lenses were fitted mostly based on the standard "three-point touch" fluorescein pattern with an appropriate centration, acceptable stability, desirable lens movement, and patient comfort. Patients with advanced KCN who required corneal contact lenses with lower base curves and lower overall diameters were excluded from the study.

The "three-point touch" is the most common fitting method used for patients with KCN. In this method, a well-distributed pressure is developed between the center of the cone and the peripheral cornea. Furthermore, it is associated with a lower risk of apical scar and a higher amount of tear exchange.[3,15] After obtaining a convenient contact lens fitting, we performed over-refraction. Then, the final power of the contact lenses was determined based on the results of over-refraction and the lens power of the trial set. All of the above procedures were performed by one experienced optometrist.

Data were analyzed in SPSS version 15 (Chicago, SPSS Inc). Simple and multiple linear regression analysis were used to investigate the relationship between lens power – as an outcome variable and corneal power and refractive errors – as predictive variables. $P < 0.05$ was considered statistically significant.

Results

In this study, we analyzed 121 eyes of 69 KCN patients (59 men) with a mean age of 23.59 ± 8.21. The results of paired *t*-test indicated a significant difference in the spherical and astigmatism refractive error before and after contact lens fitting ($P < 0.001$).

Simple linear regression confirmed that lens power has a significant direct relationship with spherical ($P < 0.001$) and equivalent spherical refractive errors ($P < 0.001$); however, no significant relationship was found between corneal power in steep and flat meridians, total refractive astigmatism, and corneal astigmatism ($P > 0.05$).

Table 1 presents the results of linear regression models of lens power in relation to the studied parameters.

Variables with a $P < 0.2$ were included in the multiple regression analysis. These variables were total corneal power, corneal power in steep and flat meridians, spherical refractive error, and equivalent spherical refractive error because the total corneal power and astigmatism are calculated based on flat and steep corneal power. In addition, equivalent

Table 1: Mean and standard deviation of studied variables and the results of simple linear regression analysis between lens power and other variables

Variables	Mean±SD	Range	Coefficient (95% CI)	*P*
Total corneal power (diopter)	49.94±4.18	42.50-59.50	−0.075 (−0.163, 0.013)	0.094
Steeper corneal power (diopter)	52.48±4.68	44-64	−0.056 (−0.135, 0.024)	0.167
Flatter corneal power (diopter)	47.40±4.05	38-59	−0.085 (−0.175, 0.005)	0.065
Corneal astigmatism (diopter)	−5.08±2.62	−12.50 - −0.25	−0.029 (−0.169, 0.111)	0.682
Spherical refraction (diopter)	−5.16±3.63	−15.25-+0.25	0.252 (0.166, 0.337)	<0.001
Refractive astigmatism (diopter)	−5.56±2.27	−10.00 - −0.75	0.089 (−0.069, 0.247)	0.266

SD: Standard deviation, CI: Confidence interval

spherical refractive error is calculated based on spherical refractive error and astigmatism. Therefore, to simplify the regression model, equivalent spherical refractive error and total corneal power were excluded from the model. The results of stepwise regression model demonstrated that the power of contact lens has a significant relationship with spherical refractive error (P < 0.001) and the power of corneal flat meridian (P = 0.001). Furthermore, this model excluded steeper cornea power due to lack of direct relationship with the lens power (P = 0.930). The estimated model of contact lens was developed as follows:

Power of contact lens = −14.368 (constant of the final multiple regression model), +0.475 (spherical refraction), and + 0.275 (flatter corneal power).

The mean and standard deviation (SD) of the power of prescribed contact lenses and the predicted power according to the regression model were − 3.77 ± 1.89 and − 3.80 ± 1.18, respectively. There was no significant difference in the power of prescribed contact lenses and the predicted power of the regression model (P = 0.875).

Discussion

Contact lenses as a nonsurgical option in KCN patients have a major role in directing the treatment process. However, fitting of corneal RGP lenses in these patients is challenging due to possible frequent replacement of trial lenses and the long duration of finding the proper fitting lens. In this study, an attempt was made to develop an appropriate regression model to estimate the power of corneal RGP contact lenses based on patients' refractive errors and corneal power. The results showed that for KCN patients with astigmatism −10.00 to −0.75 fitted with Wohlk RGP lenses (Wohlk type RGP, Conflex KE, Germany), the spherical refractive error exerts the highest impact on the power of the contact lens, so by increasing each diopter of spherical refractive error (in myopic KCN patients), the power of contact lens will increase 0.475 diopters.

Previous studies support the role of biometric parameters in predicting the initial power of contact lens in patients for whom it is not possible to accurately determine the refractive error on the lens.[16] The results of the present study also showed a significant relationship between power of corneal flat meridian that was measured by Javal keratometer and the power of contact lens. In this keratometer, the central 3 mm of the cornea, i.e., approximately 8% of the total cornea, is examined. It is the main area of corneal refraction and has a considerable relationship with refractive errors.[10,17,18] It is also considered an effective area for fitting of RGP contact lenses.[19] Furthermore, in KCN patients with corneal power equal or <55 diopters, Javal keratometer exhibited a greater repeatability than did IOL master, Orbscan, and Placido disc.[9] Therefore, in private offices and in remote areas, the power of contact lenses can be predicted by Javal manual keratometry of KCN patients with the proposed regression model. According to the results of this study, the effect of corneal flat meridian on predicting the power of contact lens was 0.275.

The results of this study showed a significant relationship between the patients' refractive error and the power of the contact lens. A notable relationship has been reported between corneal power and refractive errors, so a 0.11 diopter change in corneal power causes the refractive error to change by 1 diopter.[10] In this regard, the significant relationship we found between contact lens power and refractive error as well as flatter corneal power can be due to the correlation between flatter corneal power and refractive error that is consistent with previous studies.[10]

The results of this study showed that there is no significant relationship between the power of contact lenses and the steep power of the cornea and corneal astigmatism. The difference in the flat and steep keratometric value of cornea indicates the extent of corneal astigmatism, which in KCN patients is corrected by a tear film located below the posterior surface of the RGP contact lens, not power of contact lenses. While the results of this study showed that patients' astigmatism decreased from 5.263 ± 2.27 diopters to −0.804 ± 2.27 with corneal RGP lenses due to the role of the tear layer between the contact lens and the cornea, it also confirmed that corneal astigmatism does not play an important role in predicting the power of contact lenses. This finding, together with the reduction of spherical refractive error obtained thanks to contact lens as a predictive criterion, among others, indicates the proper fitting of contact lenses in KCN patients.

The results of this study indicated a significant relationship between the power of RGP lenses and the power of the flat corneal meridian and spherical refractive error in patients with KCN. The obtained regression model can be used to shorten patients' chair time and optometric examination for predicting the power of contact lens. This research is in line with studies in which algorithms and softwares are designed for contact lenses. Indeed, the obtained models can be effective in improving the guidelines of lens manufacturers for simplifying the fitting procedure of contact lenses.

It is recommended that similar studies should be performed with other brands of RGP trial sets in different severities of KCN, as the characteristics of each lens type or even the brands play an important role in the final lens power. It is also recommended that future studies evaluate the accuracy of the regression model obtained in this study in other samples, especially in hyperopic patients with KCN.

Financial support and sponsorship

This project was supported by Mashhad University of Medical Sciences.

Conflicts of interest

There are no conflicts of interest.

Références

1. Radner W, Zehetmayer M, Skorpik C, Mallinger R. Altered organization of collagen in the apex of keratoconus corneas. Ophthalmic Res 1998;30:327-32.
2. Vinciguerra P, Albc E, Trazza S, Rosetta P, Vinciguerra R, Seiler T, *et al.* Refractive, topographic, tomographic, and aberrometric analysis of keratoconic eyes undergoing corneal cross-linking. Ophthalmology 2009;116:369-78.
3. Rathi VM, Mandathara PS, Dumpati S. Contact lens in keratoconus. Indian J Ophthalmol 2013;61:410-5.
4. Sorbara L, Dalton K. The use of video-keratoscopy in predicting contact lens parameters for keratoconic fitting. Cont Lens Anterior Eye 2010;33:112-8.
5. Nosch DS, Ong GL, Mavrikakis I, Morris J. The application of a computerised videokeratography (CVK) based contact lens fitting software programme on irregularly shaped corneal surfaces. Cont Lens Anterior Eye 2007;30:239-48.
6. Mandathara Sudharman P, Rathi V, Dumapati S. Rose K lenses for keratoconus – An Indian experience. Eye Contact Lens 2010;36:220-2.
7. Berjandy F, Nabovati P, Hashemi H, Yekta A, Ostadimoghaddam H, Sardari S, *et al.* Predicting initial base curve of the rigid contact lenses according to Javal keratometry findings in patients with keratoconus. Cont Lens Anterior Eye 2021;44:101340.
8. Takahashi M, Kamiya K, Kono Y, Shoji N. Time course of changes in simulated keratometry and total corneal refractive power after corneal collagen cross-linking for progressive keratoconus. Biomed Res Int 2018;2018:2620784.
9. Hashemi H, Yekta A, Khabazkhoob M. Effect of keratoconus grades on repeatability of keratometry readings: Comparison of 5 devices. J Cataract Refract Surg 2015;41:1065-72.
10. AlMahmoud 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;52:1235-42.
11. Goss DA, Van Veen HG, Rainey BB, Feng B. Ocular components measured by keratometry, phakometry, and ultrasonography in emmetropic and myopic optometry students. Optom Vis Sci 1997;74:489-95.
12. Grosvenor T, Goss DA. Role of the cornea in emmetropia and myopia. Optom Vis Sci 1998;75:132-45.
13. Xu L, Wang YX, Guo Y, You QS, Jonas JB, Beijing Eye Study Group. Prevalence and associations of steep cornea/keratoconus in Greater Beijing. The Beijing Eye Study. PLoS One 2012;7:e39313.
14. Ortiz-Toquero S, Rodriguez G, de Juan V, Martin R. New web-based algorithm to improve rigid gas permeable contact lens fitting in keratoconus. Cont Lens Anterior Eye 2017;40:143-50.
15. Leung KK. RGP fitting philosophies for keratoconus. Clin Exp Optom 1999;82:230-5.
16. Trivedi RH, Lambert SR, Lynn MJ, Wilson ME, Infant Aphakia Treatment Study Group. The role of preoperative biometry in selecting initial contact lens power in the Infant Aphakia Treatment Study. J AAPOS 2014;18:251-4.
17. Ganguli D, Roy IS, Biswas SK, Sengupta M. Study of corneal power and diameter in simple refractive error. Indian J Ophthalmol 1975;23:6-11.
18. Rem.h L, Benlloch J, Furlan WD. Corneal and refractive astigmatism in adults: a power vectors analysis. Optom Vis Sci 2009;86:1182-6.
19. Donshik PC, Reisner DS, Luistro AE. The use of computerized videokeratography as an aid in fitting rigid gas permeable contact lenses. Trans Am Ophthalmol Soc 1996;94:135-43.