

## Original article

# Impact of self-contact lens fitting with uncorrected refractive error on visual acuity and lens movement in contact lens wearers

Pussadee Paensuwan\*, Pavasut Leedasawat, Wanachat Chaiyasan, Darawan Pejchang

Department of Optometry, Faculty of Allied Health Science, Naresuan University, Phitsanulok, Thailand

**Background:** Contact lenses are increasingly popular for refractive error correction. An eye examination and contact lens fitting for individual wearers are very important for best visual acuity and fitting accomplishment. Most Thai contact lens users buy their lenses from local shops and fitted the lens themselves without professional eye care services. This article reports on the impact of self-contact lens fitting on visual acuity and lens movement to establish the requirement of contact lens access control.

**Objectives:** To investigate the impact of self-contact lens fitting focusing on the uncorrected refractive error via visual acuity measurement and to determine the effect of lens base curve on lens movement in contact lens wearers.

**Methods:** A total of sixty eyes of 30 contact lens wearers were recruited. The contact lens parameters were taken from the lenses' package. Corneal curvature was determined using corneal topography. A best-corrected visual acuity and over-refraction were assessed by placing contact lens of the subjects with or without prescription using a phoropter and a distance chart for Early Treatment Diabetic Retinopathy Study (ETDRS). Lens movement was determined for a proper fitting via ocular micro-bioscope.

**Results:** All subjects used contact lenses with 8.6 mm base curves and 14.2 mm diameters. All of them bought their lenses without a prescription. There was a significant difference between corrected spherical equivalent refraction and subject's contact lens power ( $P < 0.001$ ). The poor visual acuity with the subject's lenses was significantly improved upon over-refraction ( $P < 0.001$ ). Only half of eligible eyes qualified for an optimal lens movement with their recent contact lens.

**Conclusion:** The self-contact lens fitting without eye examination might induce lens complications. There is a high prevalence of contact lens wearers who fitted their lenses depending on their own decision without an eye examination. There is 91.7% of subjects who required an over-refraction to achieve the best visual acuity. Only half of eligible eyes showed appropriate lens movement with the contact lens used. A regular contact lens assessment by eye practitioners should be done prior to and during using contact lens for improvement of best vision.

**Keywords:** Contact lenses fitting, eye practitioners, refractive errors, best-corrected visual acuity, lens movement.

The increased prevalence of correctable visual impairment has become a public health concern. Approximately, 2.3 billion people worldwide experienced visual impairment caused by uncorrected refractive (RF) error including under-corrected RF

error. <sup>(1,2)</sup> However, there are only 1.8 billion people who have access to eye examinations and appropriate correction. <sup>(3)</sup> The prevalence of visual impairment-mediated eye diseases has been known to increase with aging. <sup>(4)</sup> It has been reported that the most affected age group with visual impairment are over 50 years old, and has increased by 14% since 2004. <sup>(5)</sup> Moreover, there is a prevalence of RF error causing blindness and severe visual impairment in children globally. <sup>(1)</sup> These global burdens are correlated with the Thailand national report on major causes of visual impairment in which RF error without eye

\*Correspondence to: Pussadee Paensuwan, Department of Optometry, Faculty of Allied Health Science, Naresuan University, Tapho District, Phitsanulok, 65000, Thailand.

Email: pussadeep@nu.ac.th

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glasses was found in approximately 1.5 million Thai people. <sup>(6)</sup> A relatively high prevalence of uncorrected RF error has been found in children in the central region of Thailand, leading to 97.6% of eyes with reduced visual acuity (V.A.). <sup>(7)</sup> An uncorrected RF error can limit vision-dependent activities, resulting in a decrease of vision-related quality of life. <sup>(8)</sup> A corrective RF error can be achieved by a simple diagnosis, measurement, and correction with optical devices such as spectacles and contact lenses or refractive surgery. <sup>(9)</sup>

In Thailand, contact lenses are classified as medical devices used for vision correction or cosmetic or ocular therapy. <sup>(10)</sup> Contact lenses are becoming increasingly popular among the younger female population including college or university students, and young working adults. <sup>(11)</sup> The contact lens is a thin lens placed directly on the surface of the cornea of the eye, resulting in a wide range of ocular physiological changes. <sup>(12)</sup> There are many lines of evidence that a lens fitting is critical to contact lens practice. <sup>(13)</sup> Thus, a comprehensive eye examination and contact lens fitting with eye-care practitioners is very important for the prescription of contact lens and contact lens compliance education. <sup>(14)</sup> Previous studies have shown that there is inadequate knowledge and awareness concerning the issues related to contact lens care among Thai contact lens wearers. <sup>(15, 16)</sup> Moreover, there are insufficient eye-care practitioners to fit the lens who can afford its compliance for wearers. Furthermore, there has not been a monitoring system for a contact lens dispensation in Thailand, as stated in the laws, ophthalmologists and optometrists hold the right to prescribe and fit contact lens. In addition, the lenses have been sold in non-ophthalmic stores, markets or via the Internet.

A successful contact lens fitting leads to a sufficient distribution of the lens weight over all the corneal surface, providing the right lens position, proper lens centration and enough lens movement. <sup>(17)</sup> Lens base curve (B.C.) is a parameter that should be determined in the lens fitting practice. <sup>(17, 18)</sup> In the case that a contact lens does not fit well to the corneal curve of the wearer, contact lens-related ocular symptoms might occur. <sup>(7, 19, 20)</sup> Previous studies have shown that poor lens fitting is commonly associated with discomfort, poor V.A. and decentration from the central cornea, compared to well-fitting lenses. <sup>(12, 21, 22)</sup> However, there are very narrow choices of contact lens B.C. that are commercially available in Thailand.

Appropriate lens B.C. selection is required for fitting accomplishment and comfortable lens wear. The purpose of this present study was to investigate the influence of self-contact lens fitting focusing on the uncorrected refractive error on visual acuity and to determine the effect of lens B.C. on lens movement among contact lens wearers.

## Methods

### *Subjects enrollment*

A total of sixty eyes of 30 subjects were recruited in this study which was prospective and undertaken from a single site, the Optometry Clinic, Naresuan University (Phitsanulok, Thailand). The sample size was determined according to the principles of power analysis. The effect size was 0.50. The power of test was set at 0.90. The significance level was 0.05. The sample size was 30 people. The study abided by the tenets of the Declaration of Helsinki and was approved by the Naresuan University Institutional Review Board (IRB). Informed consent was obtained from all subjects before their recruitment after a full explanation of the nature and possible consequences of the study had been explained to them. Inclusion criteria for the subjects were as follows: current soft contact lens wearers, wearing a single vision contact lens for refractive error correction, and having good health. Exclusion criteria were as follows: ocular disease or ocular abnormalities that might interfere with wearing a contact lens, systemic diseases or under topical treatment that could suffer ocular physiology or performance of contact lens wear and wear cosmetic contact lens without refractive error. The demographic data of the subjects were collected through interviews using a questionnaire. It elicited demographic profile (i.e., age, gender, and occupation), the personal medical histories, contact lens purchasing's source, purpose of wear and type of contact lens. The subjects were interviewed and invited to participate in visual and ophthalmic examinations at the Optometry Clinic, Naresuan University.

### *Contact lens parameters determination*

The subjects were asked to bring their contact lens's packages. The contact lens parameters were taken from manufacturer's specification on the lens's packaging, including contact lens power in diopter (D), lens B.C. and lens diameter in millimeter (mm) prior to the eye examination.

### ***Corneal parameters measurement***

Corneal curvature was determined using corneal topography (model Atlas 9000, Carl Zeiss) following the procedural manufacturer's guidelines. Briefly, the contact lens fitting mode was selected. The chin of subject was placed on the chin rest, the subject's forehead was pressed against the forehead strap, and the subject's eye was aligned to the visual axis by a central fixation light. The focus was adjusted, and data were recorded.

### ***Spherical over-refraction measurement***

Spherical equivalent (SE) over-refraction was measured with the subject's contact lens to investigate whether there was any improper refractive error and to achieve the best-corrected distance V.A. Upon 30 minutes of lens wear, a spherical over-refraction was performed monocular for each eye using a phoropter and a distance chart for Early Treatment Diabetic Retinopathy Study (ETDRS). The chart had 5 letters per line arranged in 0.1 logMAR steps as specified in the ETDRS protocol. Participants started reading at +1.4 logMAR and the power was added plus or minus in 0.25 D steps until no more than one letter on a line was seen correct. Vision was scored on a letter by letter basis, assigning a score of 0.02 logMAR for each letter correctly seen.<sup>(23)</sup>

### ***Visual acuity (V.A.) test***

Visual acuity was assessed using a phoropter and an ETDRS Chart. The presenting V.A. was measured with the subjects' recent lens, recorded as "V.A. without over-refraction". The final contact lens power dispensation incorporating the SE over-refraction that resulted in best-corrected V.A. was reported to the subjects, as they can use it in purchasing their new lenses.

### ***Dynamic fitting measurement***

Lens movement was assessed for each eye after fitting with their self-buy contact lens. for at least 30 minutes, to allow the lens to fit properly to the anterior surface of the eyes. The criteria for lens movement determination are shown in Table 1.<sup>(17)</sup>

### ***Statistical analysis***

Statistical data analysis was performed using SPSS for Windows, version 23.0 (IBM Corp., New York, NY, USA). All data were tested using Shapiro-Wilk tests before the statistical analysis

for normality ( $P > 0.05$ ). Paired  $t$  tests were used to test the differences between any two parameters. Relationship between two parameters was examined by Pearson correlation analysis. As for all the parameters,  $P < 0.05$  was considered a statistically significant difference.

### **Results**

A total of 60 eyes from 30 habitual soft contact lens wear subjects were recruited and completed the study. The demographic data of participants are shown in Table 2. The mean  $\pm$  SD age of the subjects was  $22.47 \pm 3.76$  years (age range, 20 to 38 years). There was a female predominance (90%) in contact lens users in this study. All of them wore a single vision lens for visual correction. A monthly wear of contact lenses was the most common mode of lens replacement (80%) in comparison to 20% for daily disposables. These showed the increased popularity of continuous lens wear in Thai people. The average duration of contact wear was  $3.63 \pm 1.97$  years. Of the contact lens wearers, only one wearer (3.33%) fitted the lenses based on recommendations from eye practitioners in this study. We found that 96.67% fitted their lenses depending on their own decision without eye examination, based on their spectacles' power. The contact lenses were bought from optical shops, retail stores and via the Internet.

### ***Parameters of cornea and contact lens***

Given from the lenses' packages of the individual subjects, all of them represented 8.6 mm lens base curve and 14.2 mm lens diameter. The mean  $\pm$  SEM contact lens power of subjects' contact lens was  $-2.90 \pm 0.15$  D, ranged from -1.25 to -6.00 D. These indicated that all subjects had myopic eyes. The mean flat and steep K readings of the eyes were  $43.31 \pm 1.12$  D (range, 40.23 to 45.32) and  $44.85 \pm 1.21$  D (range, 42.40 to 47.29 D), respectively. The mean ( $\pm$  SEM) corneal base curve radius and diameter were  $7.79 \pm 0.03$  mm and  $12.37 \pm 0.04$  mm, respectively. There was a significant difference in B.C. and diameter between the cornea and the subject's contact lens ( $P < 0.001$ ) as shown in Table 3.

### ***Spherical Over-refraction***

The spherical over-refraction was required to achieve best-corrected distance visual acuity. The mean  $\pm$  SEM spherical over-refraction with by placing

contact lens of subjects was  $-0.66 \pm 0.06$  D (range,  $-1.75 - 0.25$  D). The majority range of spherical over-refraction was between 0.00 to  $-1.00$  D as shown in Figure 1. The result showed that 91.7% of the subjects wore contact lens with lower power compared with their corrected refractive error. The mean ( $\pm$  SEM)

corrected refractive power of the subjects following over-refraction was  $-3.57 \pm 1.32$  D, whereas the mean power of recent contact lens was  $-2.90 \pm 1.13$  D. There was a significant difference between corrected refractive power and subjects' contact lens power ( $P < 0.001$ ) as shown in Table 3.

**Table 1.** Criteria for lens movement assessment.

Grade	Description	Explanation
-1	Less lens movement	Lens moves less than 0.2 mm after blinking
0	Optimal	Lens moves 0.2 to 0.4 mm after blinking
+1	Excess lens movement	Lens moves more than 0.4 mm after blinking

**Table 2.** Demographic characteristics of participants.

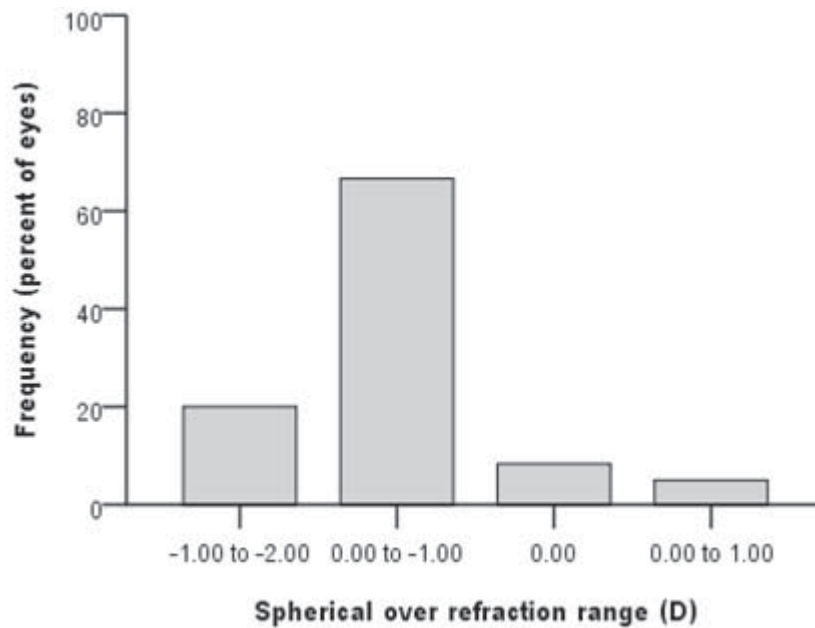
Demographic factors	Subjects (N = 30)
Sex (male: female)	3:27 (10%: 90%)
Age	$22.47 \pm 3.76$ years
<b>Profession</b>	
Student	27 (90%)
Office worker	3 (10%)
<b>Mode of lens replacement</b>	
Daily disposable	6 (20%)
Monthly disposable	24 (80%)
<b>Lens wear experiences</b>	$3.63 \pm 1.97$ years
<b>Method/place of lens purchase</b>	
Eye practitioner	1 (3.33%)
Optical store without eye examination	23 (76.67%)
Retail store without eye examination/Internet	6 (20%)

**Table 3.** Parameters of cornea and contact lens.

Parameters	Cornea	Contact lens	P - value
Base curve (mm)	$7.79 \pm 0.03$	$8.60 \pm 0.00$	$< 0.001^*$
Diameter (mm)	$12.37 \pm 0.04$	$14.20 \pm 0.00$	$< 0.001^*$
Spherical refraction (D)	$-3.57 \pm 1.32$	$-2.9 \pm 0.15$	$< 0.001^{**}$

\*P - value is based on independent T-test.

\*\*P - valued is based on paired T-test

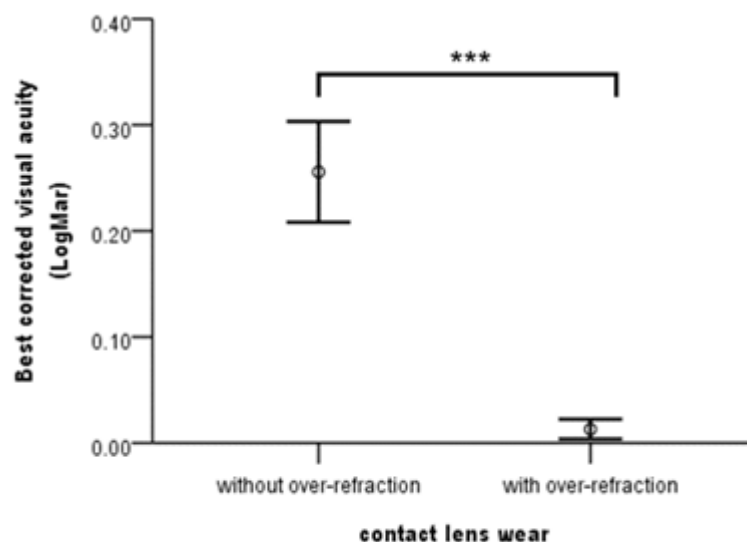


**Figure 1.** The frequency distribution percentage of spherical over-refraction values (60 eyes in total).

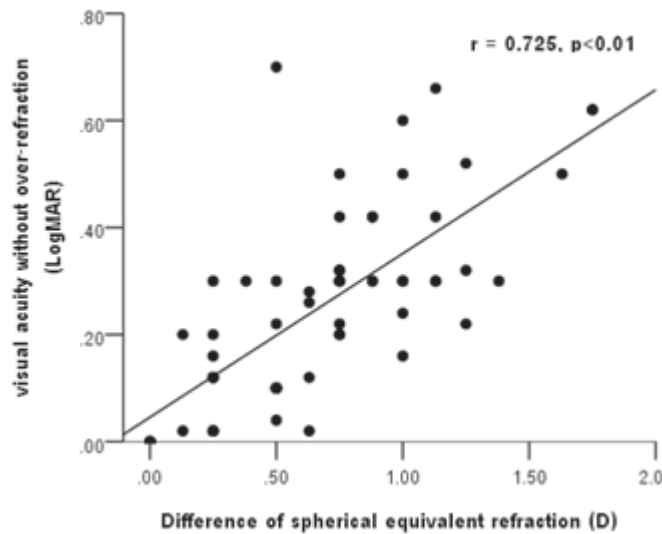
**Visual acuity**

The mean ( $\pm$  SEM) V.A. by placing the contact lens of the subjects without over-refraction for each eye was  $0.26 \pm 0.02$  logMAR, and ranged from 0.00 to 0.70 logMAR. The mean corrected V.A. by placing the same contact lens with over-refraction was  $0.01 \pm 0.005$  logMAR, and ranged from 0.00 to 0.16 logMAR. After over-refraction, the V.A. values were nearest or equal to 0.00 logMAR, indicating that the V.A. was markedly improved with proper contact lens prescription. There was a statistically significant difference in V.A. by placing the contact lens between with and without correcting with over-refraction ( $P < 0.001$ ) as shown in Figure 2. There was a strong

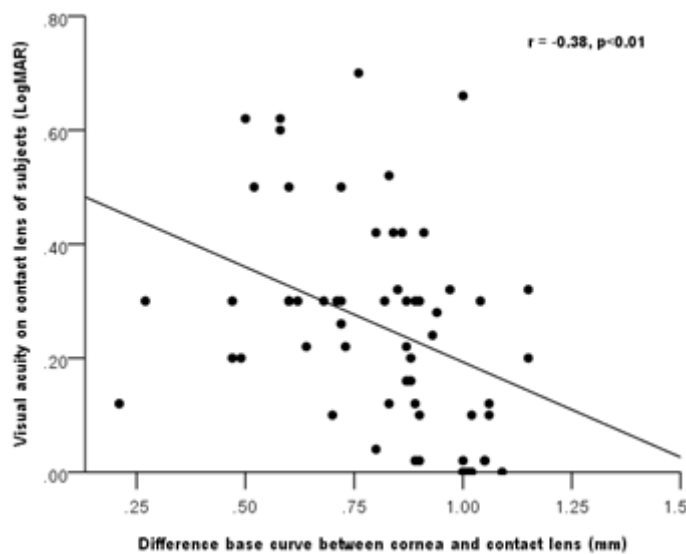
significant positive correlation between the V.A. without over-refraction and the power adding during the over-refraction process (Figure 3). The difference of the refractive power under over-refraction was increased corresponding to an increasing of V.A. Moreover, there was a significant negative correlation between the visual acuity and the difference of base curve between lens base curve and corneal base curve (Pearson correlation coefficient,  $r = -0.38$ ,  $n = 60$ ,  $P < 0.01$ ) (Figure 4). Our study indicates that the optimal difference between lens base curve and corneal base curve should be determined for proper lens fitting.



**Figure 2.** The best-corrected visual acuity (LogMAR) on soft contact lens with or without spherical over-refraction for each eye. (Paired *t*-test, error bars represent SEM,  $n = 60$ ,  $P < 0.001$ )



**Figure 3.** Correlation between the visual acuity without over-refraction and the difference of spherical equivalent refraction under corrected spherical equivalent refraction and power of contact lens. (Pearson correlation coefficient,  $r = 0.725$ ,  $n = 60$ ,  $P < 0.01$ ).



**Figure 4.** Correlation between the visual acuity and the difference of base curve between lens base curve and corneal base curve. (Pearson correlation coefficient,  $r = -0.38$ ,  $n = 60$ ,  $P < 0.01$ ).

#### *Dynamic fit*

The mean ( $\pm$  SEM) post-blink movement in primary gaze was  $0.48 \pm 0.04$  mm. The criteria for lens movement assessment are shown in Table 1.<sup>(17)</sup> Fifty-five percent of the study eyes fitted with

8.6 mm base curve lenses, showed an optimal lens movement characteristic, ranged from 0.2 to 0.4 mm movement (Table 4). However, 40% of the fitted eyes corresponding lens movement was found to be excessive.

**Table 4.** Frequency of lens movement assessment (n = 60).

Grade	Description	Eyes number (%)
-1	Less lens movement	3 (5%)
0	Optimal	33 (55%)
+1	Excess lens movement	24 (40%)

**Discussion**

Contact lenses are optical devices which are becoming relatively popular in the young generation. <sup>(11, 24, 25)</sup> We found that all participants wore a soft contact lens. This might be due to a comfortable wearing while minimizing poor effects on ocular physiology. <sup>(14, 18)</sup> The predominance of contact lens users in this study was female. This trend is consistent as females make up the majority of wearers globally. <sup>(26)</sup> This is attributed to a strong desire to avoid the use of spectacles or to alter a good personal appearance. All subjects used contact lenses for refractive correction purposes, correlated the findings that all had myopic eyes. A monthly wear of contact lenses was the most common mode of lens replacement, revealing a popular increase in continuous lens wearing among Thai contact lenses wearers. This might be from a yearly cost of contact lenses, as the daily disposables wear lenses are 5 times higher in prices even if it is more safer and easier in care. The assessment of the contact lens fitting is important in contact lens practice depending on corneal and contact lens parameters. An inappropriately contacting lens fit could lead to visual disturbances and ocular diseases. <sup>(12, 19, 27, 28)</sup> As there is a limitation of eye-care practitioners in Thailand, it is not surprising that the subjects have not met eye-care practitioners for a prescription before purchasing contact lenses. This might be from a lack of knowledge and awareness of proper lens use and care. We found that it seems to be quite easy to buy contact lenses. In Thailand, contact lenses are often seen displayed on the shelves of unauthorized stores, markets and on the Internet. Moreover, poor soft contact lens fitting has been shown to be associated with discomfort, poor vision and ocular physiology change. <sup>(13, 14, 21)</sup> Given the results, all subjects wore the uncorrected contact lens power with their refractive error, resulting in improper visual acuity. These might be caused by a quite convenient contact lens access without prescription from eye-care practitioners. It has been shown that uncorrected refractive error is

associated with decreased vision-related quality of life. <sup>(1, 8)</sup> We found that the V.A. of the subjects for each eye was improved upon spherical over-refraction. This confirms that the subjects used the improper contact lens’s power. There are ‘myopic shifts’ reported during soft lens wear. <sup>(29)</sup> Furthermore, the significant increase of myopia could be observed up to and over 1 D. <sup>(29, 30)</sup> Thus, the refractive error can be altered during lens wear which indicates that a refractive examination should be undertaken regularly. Due to inadequate knowledge, some subjects still prefer to use the power of contact lens predicting from their old refractive errors.

Contact lens fitting requires eye-care practitioners, ophthalmologists and optometrists, to select the best fit for individual wearers. A successful contact lens fitting is defined in terms of a “good” or “poor” fitting. <sup>(14)</sup> A good lens fitting has optimal lens centration and movement after blinking, while poor fitting shows marginally tight or loose wear. <sup>(28)</sup> Both corneal and contact lens parameters are simultaneously assessed for contact lens practice. <sup>(14)</sup> The base curve of a lens may affect certain aspects of vision including distortion and magnification. <sup>(31)</sup> The perceptual differences between lenses with different base curves has been found among contact lens wearers. <sup>(17, 32)</sup> Moreover, we found that all eligible wearers did not determine the suitable lens base curve for their eyes before buying. This would be related to a lack of understanding in contact lens prescribing. However, the commercially available contact lenses in Thailand tend to lie in a narrow range of B.C. and diameter. This might indicate that the majority of manufacturers have selected the average range of corneal B.C. in the Thai population. To benefit of a narrow range of the lens parameters on offer is limited control over fitting characteristics and might be helpful for manufacturers to limit the required inventory where there is limited access to lens fitting, as in Thailand. We found that all the assessed lenses in this study were 8.6 mm of base curve and 14.2 mm of lens diameter. It indicates that these one-fit contact lenses are prevalent and might be designed to provide an optimal base curve and diameter for fitting virtually the entire Thai population. It has been shown that the highest rate of fitting success was achieved with an 8.60 mm base curve lens and 14.2 mm lens diameter in eyes, which had the mean K reading and corneal base curve radius closest to the eyes in this study using a mathematical model. <sup>(32)</sup> Thus, an available

contact lens tested in this study might dispense to fit the widest possible range of Thai's eyes with a proper fit. In our study, a correlation of corneal parameters and contact lens parameter was evaluated for proper available contact lens fit. Interestingly, only half of eligible eyes had optimal lens movement in an accepted range. There was no correlation regarding 8.6 mm base curve contact lenses between lens movement and corneal base curve. It might be that only the corneal base curve parameter is not enough for proper contact lens fitting.<sup>(32, 33)</sup>

In summary, our results suggest that a regular contact lens assessment by eye practitioners should be done prior to and during the use of contact lenses. This current study highlights the requirement of laws mandating the dispensing of contact lenses to limit the abuse of contact lens dispensation and to improve the general health condition of the increasing population of contact lens wearers.

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### Conflict of interest

None of the authors has any potential conflict of interest to disclose.

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