**Influence of uncorrected refractive error and self- contact lens fitting on visual acuity and lens movement among contact lens wearers in Phitsanulok**

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**Abstract**

**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. As eye practitioners are not sufficient in Thailand, most of the contact lens users bought their lenses from non-professional eye cares. Moreover, there is a base curve limitation of available contact lens, so it is necessary to determine the suitable lenses for most Thai wearers.

**Objectives**

 To investigate the influence of the uncorrected refractive error on visual acuity and to determine the effect of lens base curve on lens movement among contact lens wearers.

**Methods**

 A total of sixty eyes of 30 contact lens wearers was enrolled. The contact lens parameters were taken from the lens’s 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 over-refraction using a phoropter and a distance Early Treatment Diabetic Retinopathy Study (ETDRS) chart. Lens movement was determined for a proper fitting via ocular microbioscope.

**Results**

All subjects used contact lenses with 8.6 mm base curve and 14.2 mm diameter. All of them bought their lenses without prescribing. There was a significance 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 that were qualified for an optimal lens movement with their recent contact lens.

**Conclusion**

There is typically required an over-refraction to achieve the best visual acuity among Thai contact lens wearers. Only a half of eligible eyes showed an appropriate lens movement with their contact lens used. A regular contact lens assessment by eye practitioners should be done prior to and during using contact lens for improvement of vision-related quality of life.

**Keywords**

Contact lenses fitting, eye practitioners, refractive errors, best-corrected visual acuity, lens movement

**ผลกระทบของการไม่ได้รับการแก้ไขภาวะสายตาผิดปกติและการเลือกสวมใส่เลนส์สัมผัสด้วยตนเองต่อระดับความสามารถในการมองเห็นและการเคลื่อนตัวของเลนส์ในกลุ่มผู้สวมใส่เลนส์สัมผัส จังหวัดพิษณุโลก**

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**ที่มาของงานวิจัย**

 เลนส์สัมผัส ได้รับความนิยมเพื่อช่วยแก้ไขภาวะสายตาผิดปกติ การตรวจสายตาและความพอดีของเลนส์สัมผัสให้กับผู้สวมใส่จึงมีความสำคัญ เพื่อให้มีระดับความสามารถในการมองเห็นที่ดีที่สุดและการสวมใส่มีความเหมาะสม การมีผู้เชี่ยวชาญด้านสายตาไม่เพียงพอในประเทศไทย ผู้สวมใส่จึงมีเลือกซื้อเลนส์สัมผัสด้วยตนเอง อีกทั้งการมีค่าความโค้งของเลนส์อย่างจำกัด จึงควรมีการพิจารณาความเหมาะสมของเลนส์สัมผัสต่อตาของคนไทย

**วัตถุประสงค์**

 เพื่อศึกษาผลของการสวมใส่เลนส์สัมผัสที่มีค่าสายตาไม่ถูกต้องต่อระดับความสามารถในการมองเห็น และผลของค่าความโค้งเลนส์ต่อการเคลื่อนตัวของเลนส์ในกลุ่มผู้สวมใส่เลนส์สัมผัส

**วิธีการทำวิจัย**

 ทำการศึกษาในอาสาสมัครผู้สวมใส่เลนส์สัมผัส 30 คน จำนวน 60 ตา บันทึกค่าพารามิเตอร์เลนส์จากบรรจุภัณฑ์เลนส์สัมผัส, วัดค่าความโค้งกระจกตา, วิเคราะห์ระดับการมองเห็นเมื่อสวมใส่เลนส์สัมผัส ทั้งที่ไม่ได้รับและได้รับการแก้ไขค่าสายตา และตรวจวัดการเคลื่อนตัวของเลนส์

**ผลการศึกษา**

 อาสาสมัครสวมใส่เลนส์สัมผัสที่มีค่าความโค้งเลนส์ 8.6 มิลลิเมตรและเส้นผ่านศูนย์กลางเลนส์ 14.2 มิลลิเมตร มีการเลือกซื้อเลนส์สัมผัสโดยไม่ได้รับการสั่งจ่าย มีความแตกต่างระหว่างค่าสายตาที่ได้รับการแก้ไขกับค่าสายตาของเลนส์สัมผัสที่สวมใส่อย่างมีนัยสำคัญ (p<0.001) มีระดับการมองเห็นที่ดีขึ้นเมื่อได้รับค่าสายตาที่ถูกต้อง (p<0.001) มีตาเพียงครึ่งหนึ่งที่มีการเคลื่อนตัวของเลนส์เหมาะสม

**สรุป**

 การแก้ไขค่าสายตาในกลุ่มผู้สวมใส่เลนส์สัมผัสถูกต้องการเพื่อให้มีระดับการมองเห็นที่ดีที่สุด มีจำนวนตาเพียงครึ่งหนึ่งที่มีการเคลื่อนตัวเลนส์อย่างเหมาะสม การตรวจความพอดีของเลนส์สัมผัสกับผู้เชี่ยวชาญจึงควรทำทั้งก่อนการใส่และในระหว่างการใส่เลนส์สัมผัส

**คำสำคัญ**

การตรวจความพอดีเลนส์สัมผัส, ผู้เชี่ยวชาญด้านสายตา, สายตาผิดปกติ, ระดับความสามารถการมองเห็นที่ดีที่สุด, การเคลื่อนตัวเลนส์

**Introduction**

The increased prevalence of correctable visual impairment has become a public health concern. Approximately 2.3 billion population worldwide experienced visual impairment causing from uncorrected refractive (RF) error including undercorrected RF error [1](#_ENREF_1), [2](#_ENREF_2). However, there are only 1.8 billion people who have access to eye examinations and appropriate correction [3](#_ENREF_3). The prevalence of visual impairment-mediated eye diseases has been known to increase with age [4](#_ENREF_4). It has been reported that the most affected age group with visual impairment are over 50 years old, which has increased by 14%, since 2004 [5](#_ENREF_5). Moreover, there is a prevalence of RF error causing blindness and severe visual impairment in children globally[1](#_ENREF_1). These global burdens are correlated with Thailand national report on the major cause of visual impairment in which RF error without eye glasses found in estimated 1.5 million Thai people [6](#_ENREF_6). 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.) [7](#_ENREF_7). An uncorrected RF error can limit vision-dependent activities resulting in a decrease of vision-related quality of life [8](#_ENREF_8). 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 [9](#_ENREF_9).

 In Thailand, the contact lens is classified as a medical device used for vision correction or cosmetic or ocular therapy [10](#_ENREF_10). Contact lenses are becoming increasingly popular among the female younger population including college or university students and young working adults [11](#_ENREF_11). 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 [12](#_ENREF_12). There are many lines of evidence that a lens fitting is critical to contact lens practice [13](#_ENREF_13). 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[14](#_ENREF_14). Previous studies have shown that there are inadequate knowledge and awareness concerning issues related to contact lens care among Thai contact lens wearers [15](#_ENREF_15), [16](#_ENREF_16). Moreover, there are insufficient eye-care practitioners to fit the lens and 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, ophthalmologist and optometrist hold the right to prescribe and fit contact lens. In addition, the lenses have been sold in non-ophthalmic stores, market or internet.

 A successful contact lens fitting leads to a sufficient distribution of the lens weight over all the corneal surface, providing a right lens position, proper lens centration and enough lens movement [17](#_ENREF_17). Lens base curve (B.C.) is a parameter that should be determined in lens fitting practice [17](#_ENREF_17), [18](#_ENREF_18). In case of contact lens does not fit well to the corneal curve of wearers, contact lens- related ocular symptoms might occur [17](#_ENREF_17), [19](#_ENREF_19), [20](#_ENREF_20). Previous studies have shown that poor lens fitting are commonly associated with discomfort, poor V.A. and decentration from the central cornea, compared to well-fitting lenses [12](#_ENREF_12), [21](#_ENREF_21), [22](#_ENREF_22). However, there are very narrow choices of contact lens B.C. that are commercially available in Thailand. The 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 improper R.E. to V.A. 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 enrolled in this present the study. This study was prospective and undertaken from a single site, the Optometry clinic, Naresuan University (Phitsanulok, Thailand). The study protocol adhered to the tenets of the Declaration of Helsinki and was approved by the Naresuan University Institutional Review Board. Informed consent was obtained from all subjects before their participation in the study after a full explanation of the nature and possible consequences of the study had been explained to them. Inclusion criteria for the subjects were: current soft contact lens wearers, wear a single vision contact lens for refractive error correction and healthy. Exclusion criteria included ocular disease or ocular abnormalities that might interfere contact lens wear, 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 interviewed 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 who were interviewed were invited to participate in visual and ophthalmic examinations at Naresuan University optometry clinic.

**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 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 was 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 Early Treatment Diabetic Retinopathy Study (ETDRS) Chart. 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 [23](#_ENREF_23).

**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’s 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 were assessed for each eye after fitting with subject’s contact lens. The criteria for lens movement determination are shown in the table 1 [17](#_ENREF_17).

**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 for differences between any two parameters. The relationship between two parameters was examined by Pearson correlation analysis. For all the parameters, *p* < 0.05 was considered significant.

**Result**

A total of 60 eyes from 30 habitual soft contact lens wear subjects was enrolled in and complete the study. The demographic data of participants are shown in table 1. The mean (±SD) age of the subjects was 22.47±3.76 years (age range, 20 to 38 years). There was a female predominance (90%) in contact lens user of 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 the continuous lenses wear among Thai wearers. The average duration of contact wear was 3.63 ± 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 spectacle’s power. The contact lenses were bought from optical shop, retail store and internet.

**Parameters of cornea and contact lens**

Given from the lens’s packages of the individual subjects, all of them represented 8.6 mm lens base curve and 14.2 mm lens diameter. The mean (±SEM) contact lens power of subject’s contact lens was -2.90 ± 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 that were 43.31 ± 1.12 D (range, 40.23 to 45.32 and 44.85 ± 1.21 D (range, 42.40 to 47.29 D), respectively. The mean (±SEM) corneal base curve radius and diameter were 7.79 ± 0.03 mm and 12.37 ± 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 Table 2.

**Spherical Over-refraction**

The spherical over-refraction was required to achieve best -corrected distance visual acuity. The mean (± SEM) spherical over-refraction with by placing contact lens of subjects was -0.66 ± 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 comparing with their corrected refractive error. The mean (± SEM) corrected refractive power of the subjects following over-refraction was -3.57 ± 1.32 D whereas the mean power of recent contact lens was -2.94 ± 1.13 D. There was a significant difference between corrected refractive power and subject’s contact lens power (p<0.001) as shown in Table 2.

**Visual acuity**

The mean (± SEM) V.A. by placing contact lens of the subjects without over-refraction for each eye was 0.26 ± 0.02 logMAR, 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 ± 0.005 logMAR, 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 precribing. 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 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 negative correlation between the visual acuity and the difference of base curve between lens base curve and corneal base curve significantly (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.

**Dynamic fit**

The mean (± SEM) post blink movement in primary gaze was 0.48 ± 0.04 mm. The criteria for lens movement assessment are shown in table 1 [17](#_ENREF_17). Fifty-five percent of eyes can be fitted 8.6 mm base curve lens, showed an optimal lens movement characteristic, ranged from 0.2 to 0.4 mm (Table 4). However, 40% of the fitted eyes corresponding lens movement was found to be excessive.

**Discussion**

Contact lens are optical devices which are becoming popularity, relatively in young generation [11](#_ENREF_11), [24](#_ENREF_24), [25](#_ENREF_25). We found that all participants wore a soft contact lens. This might be due to a comfortable wearing with minimizing poor effects on ocular physiology [14](#_ENREF_14), [18](#_ENREF_18). The predominance of contact lens users in this study was female. This trend is consistent with females made up the majority of wearers globally [26](#_ENREF_26). This is attributed to a strong desire to avoid the use of spectacles or to alter a good personal appearance. All subjects used contact lens for refractive correction purpose, 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 increasing of the continuous wear lenses used among Thai contact lens wearers. This might be from a yearly cost of contact lens, as the daily disposables wear was 5 times higher in prices even if it is more safety 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 contact lens fit could lead to visual disturbances and ocular diseases [12](#_ENREF_12), [19](#_ENREF_19), [27](#_ENREF_27), [28](#_ENREF_28). As the 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 lens. 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 lens. Contact lens are often seen displayed on the shelves of unauthorized stores, market and on internet in Thailand. Moreover, The poor soft contact lens fitting has shown to be associated with discomfort, poor vision and ocular physiology changes [13](#_ENREF_13), [14](#_ENREF_14), [21](#_ENREF_21). Given the results, all subjects wore the incorrected contact lens power with their refractive error, resulting in improper visual acuity. These might be caused from a quite convenient contact lens access without prescription with eye-care practitioners. It has been shown that uncorrected refractive error is associated with decreased vision-related quality of life [1](#_ENREF_1), [8](#_ENREF_8). We found that the V.A. of the subjects for each eye was improved upon spherical over-refraction. This confirms that subjects used the improper contact lens’s power. There are a ‘myopic shifts’ reported during soft lenses wear [29](#_ENREF_29). Furthermore, the significant increase of myopia could be observed up to and over 1 D [29](#_ENREF_29), [30](#_ENREF_30). Thus, the refractive error can be altered during lens wear which indicates that a refractive examination should be undertaken regularly. As inadequate knowledge, some subjects still prefer to use the power of contact lens predicting from their old refractive errors.

The contact lens fitting requires eye-care practitioners, ophthalmologist and optometrist, to select the best fit for individual wearers. A successful contact lens fitting are defined in term of “good” or “poor” fitting [14](#_ENREF_14). The good lens fitting has optimal lens centration and movement after blinking, while poor fitting shows marginally tight or loose wear [28](#_ENREF_28). Both corneal and contact lens parameters are simultaneously assessed for contact lens practice [14](#_ENREF_14). The base curve of a lens may affect certain aspects of vision including distortion and magnification [31](#_ENREF_31). The perceptual differences between lenses with different base curves has been found among contact lens wearers [17](#_ENREF_17), [32](#_ENREF_32). Moreover, we found that all eligible wearers did not determined the suitable lens base curve for their eyes before buying it. This would be related to a lack of understanding in contact lens prescribing. However, the commercially available contact lens in Thailand tend to lie in a narrow range of B.C. and diameter. This might indicate that majority of manufacturers have selected the average range of corneal B.C. in Thai population. Benefit of a narrow range of the lens parameters offering is a limited control over fitting characteristics and might be helpful for manufacturers to limits the required inventory in the limited contact lens fitting as in Thailand. We found that all the assessed lens in this study was 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 [32](#_ENREF_32). Thus, an available contact lens tested in this study might dispense to fit the widest possible range of Thai’s eyes with a proper fitting. In our study, a correlation of corneal parameters and contact lens parameter was evaluated for proper available contact lens fit. Interestingly, only a half of eligible eyes has an optimal lens movement in an accepted range. There was no correlation regarding 8.6 mm base curve contact lens between lens movement and corneal base curve. It might be that only corneal base curve parameter is not enough for proper contact lens fitting [32](#_ENREF_32), [33](#_ENREF_33).

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

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**Conflict of interest**

The authors have no conflicting interests.

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**Tables and Figures**

**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±3.76 years |
| ProfessionStudentOffice worker | 27 (90%) 3 (10%) |
| Mode of lens replacementDaily disposableMonthly disposable |  6 (20%)24 (80%) |
| Lens wear experiences | 3.63 ± 1.97 years |
| Method/place of lens purchaseEye practitionerOptical store without eye examination Retail store without eye examination/Internet | 1 (3.33%)23 (76.67%)6 (20%) |

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

|  |  |  |  |
| --- | --- | --- | --- |
| parameters | Cornea | Contact lens | P-value |
| Base curve (mm) | 7.79 ± 0.03 | 8.60 ± 0.00 | <0.001\* |
| Diameter (mm) | 12.37 ± 0.04 | 14.20 ± 0.00 | <0.001\* |
| Spherical refraction (D) | -3.57 ± 1.32 D | -2.9 ± 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)

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**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)

****

**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%) |