Role of Short Term Open Eye Orthok Lens Wear in Inducing Myopia Control Changes in Eyes with Moderate Myopia

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Abstract

Purpose: To assess peripheral refraction, corneal, and visual acuity changes after open eye use of orthokeratology (OrthoK) contact lenses.

Methodology: OrthoK contact lenses were worn on separate occasions for half an hour and 2 hours in open eye condition. The peripheral refraction (PR) changes were assessed monocularly up to 30° nasally and temporally in the horizontal visual field using the open field autorefractometer. Average corneal power (ACP), central corneal thickness (CCT), and visual acuity (VA) was recorded using corneal topographer, specular microscope, and LogMAR chart respectively.

Results: Mean baseline PR at 25° and beyond both nasally and temporally was -0.54 ± 1.68D (mean ± SD) which increased to mean -1.29 ± 1.43D ($p < 0.01$) post half an hour of lens wear and further increased to mean -1.62 ± 1.53D ($p < 0.01$) after 2 hours lens wear. The mean baseline ACP was 43.45 ± 1.34D that reduced to mean 43.11 ± 1.37D ($p < 0.01$) after half an hour of lens wear and a further reduction to mean 42.73 ± 1.34D ($p < 0.01$) 2 hours post lens wear. Mean CCT changes after half an hour lens wear were not significant but it reduced by mean 14.92 ± 4.68 µm ($p < 0.01$) 2 hours post lens wear as compared to baseline. The unaided VA improved from mean 0.85 + 0.37 log at baseline to mean 0.49 + 0.35 log ($p < 0.01$) after half an hour of lens wear and mean 0.39 + 0.35 log ($p < 0.01$) after 2 hours of OrthoK lens wear.

Conclusion: Rapid corneal and peripheral refraction shifts are seen after half an hour of open-eye wear of the OrthoK lens with a gradual rise in impact for 2 hours of lens wear.

Keywords: *Orthokeratology, peripheral refraction, myopia.*

Introduction

Overnight orthokeratology (OrthoK) wear using reverse geometry lenses has proven to be an effective procedure for vision correction option since past few decades.[1, 2] Researchers have also proven its efficacy in myopia control by inducing peripheral myopic defocus in children and teens.[3-7] Reduction in central corneal thickness (CCT), flattening of corneal curvature, and improvement of visual acuity (VA) have also been reported post first overnight wear of OrthoK lenses.[6] Peripheral myopic refraction changes post-OrthoK lens wear have a strong correlation with corneal flattening and daily usage of these lenses ensures myopia control in the young population.[7] Although overnight OrthoK wear is mostly safe, a few studies[8, 9] have reported an increased incidence of corneal infection and lens binding post overnight OrthoK wear. Reducing the risk of overnight wear would increase its acceptance among practitioners as well as patients. A short term day time use may be the right solution to utilize the advantages of changes in peripheral refraction without the risk of development of ocular infection. Daytime OrthoK lens wear could be a

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potential method for reducing myopia progression.

This study aims to record changes post short term, day-time, open eyewear of OrthoK lenses on average corneal power (ACP), CCT, VA along with changes in peripheral refraction (PR). Based on the above ocular response to short term OrthoK lens wear it will be of interest if routine short term daytime wear of OrthoK lenses leads to myopia control.

Material and Methods

This study recruited subjects from the student population of Lotus College of Optometry, Mumbai, India. After the explanation of study procedures in detail, written informed consent was taken from all subjects. No subjects reported a history of any ocular diseases or corneal ectasia and none were previous RGP lens wearers or extended soft lens wearers. Only subjects with a refractive error between –1.00DS to –4.00DS and with the rule astigmatism less than 1.50DC were included in the study.

This study used reverse geometry RGP contact lenses manufactured by Fargo (GP Specialist, USA). The lenses were made of Paragon HDS material with a Dk value of 100. The lenses were fitted as per the guidelines of the manufacturer that takes into account the subject's corneal curvature and refraction. Slit-lamp fluorescein fitting evaluation was performed for good lens centration and movement with every blink.

The open field auto-refractometer WAM-5500 (Grand Seiko Co. Ltd, Japan) was used to record PR monocularly at baseline and post lens wear. In order to dilate the pupil for ease in the measurement of PR, the illumination of the room was dimmed. To record peripheral refraction a curved rail was designed and mounted at a distance of 2.50m from the subject's corneal apex (Figure 1). The curve mount was specifically designed to ensure all measurement LED points are equidistant from the subject's corneal apex. A total of five readings were taken at each point and averaged for the best accuracy. The instrument's conventional refraction values were converted to vector form of spherical equivalent 'M' and peripheral astigmatism form J180/J45 by the computer software for analysis. ACP was recorded using the TMS-4 corneal topographer (Tomey Corporation, USA). The topographer software records the ACP by averaging all the corneal data points on the reflected mires ahead of the entrance pupil. Accurate ACP values were recorded by capturing three corneal image maps with good centration and later averaging their values. CCT values were recorded using a non-contact specular microscope SP-3000P (Topcon Corporation, Japan) and a total of three readings were recorded and averaged. Monocular VA was recorded using a LogMAR chart under standard room illumination of 120 cd/m^2.

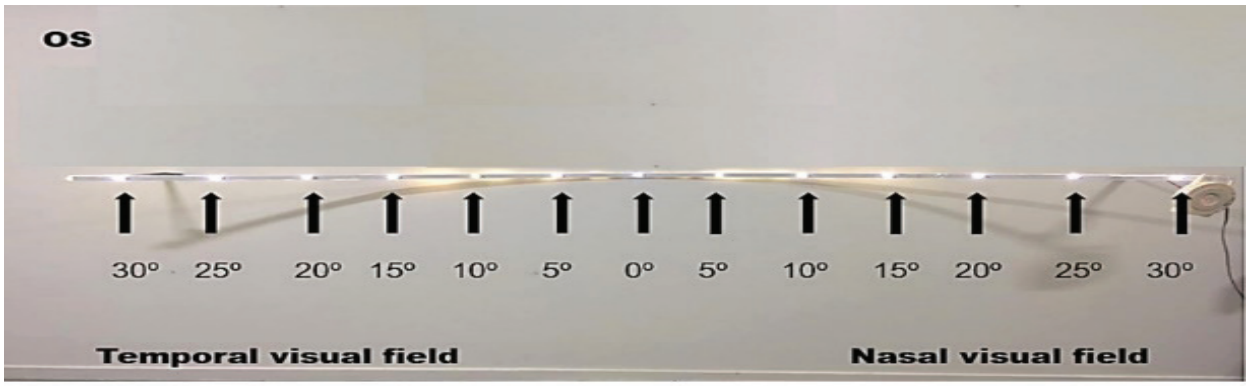

Figure 1: Fixation LED points located at 2.5m from the subject at 5^o interval representing visual field eccentricities for measuring peripheral refraction. Prefix 'OS' denotes the left eye.

Study protocol: Detailed slit-lamp examination and non-cycloplegic refraction were performed to observe overall ocular health and to ensure subjects met the selection criteria. This study was divided into three visits; one baseline and 2 test visits. The baseline measurements during the first visit included VA, ACP, CCT, and PR. Subjects then wore best-fit OrthoK lenses in both eyes for half an hour in open eye condition on the second visit. A single examiner inserted and removed the OrthoK lenses during the same time of the day to avoid diurnal variations. Post half an hour wear lenses were removed and refraction; VA, ACP, CCT, and PR were recorded monocularly in the same sequence for all subjects. The subjects were then recalled after a week for the third visit that included OrthoK lens wear for 2 hours in open eye condition and again all values were recorded monocularly and compared to baseline. This was performed to ascertain if there were any further changes in ocular measurements with longer duration of lens wear.

Data Analysis: Data were analyzed using SPSS software (version 20). Kolmogorov-Smirnov test was done to evaluate the normality of the data distribution. Repeated measures ANOVA with posthoc test (Bonferroni correction) was used when the data passed the normality test. The study chose a critical *p*-value of 0.05 or less for statistical significance.

Results

This study included 25 eyes of 15 subjects with a mean age of 20.45 ± 1.45 years (mean ± SD) were recruited for the study. The mean objective baseline central refraction of the subjects was –2.52 ± 1.15 D (mean ± SD).

Compared to the baseline mean refraction in central 10º of visual field reduced by -0.36 ± 0.26 D (mean ± SD) post 30 min lens wear and -0.63 ± 0.32 D (mean ± SD) post 2 hours lens wear and was statistically significant ($p < 0.01$) for both lens wear duration as observed in figure 2.

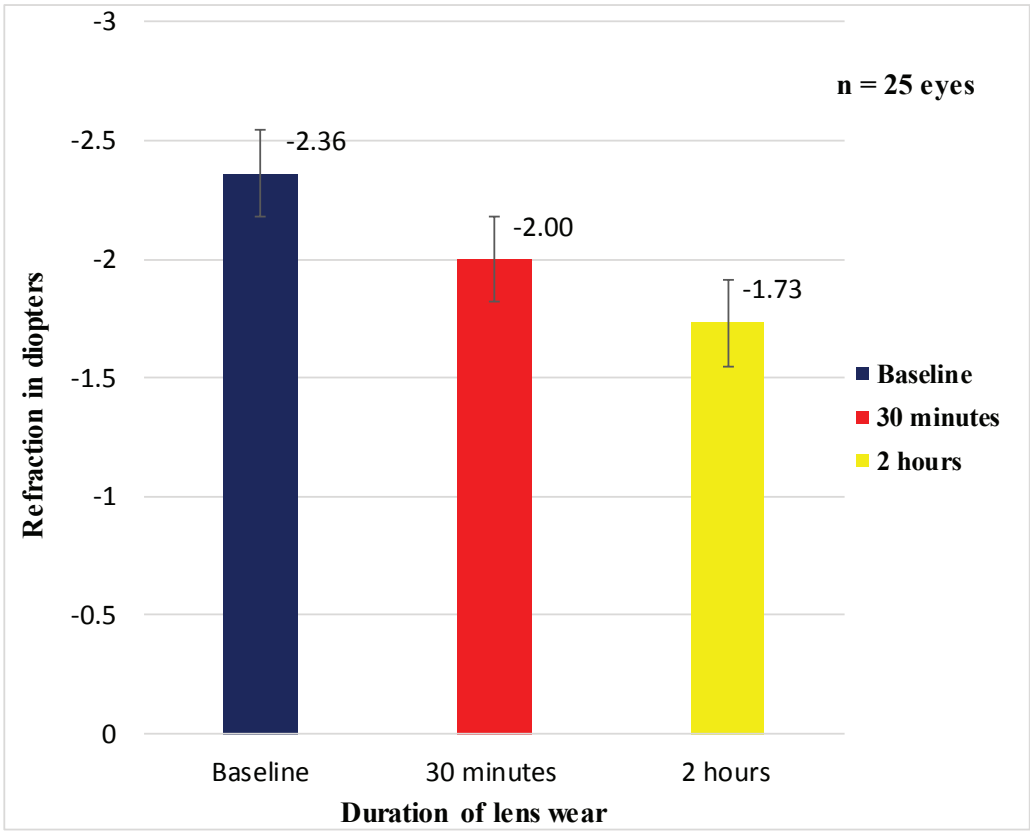

Figure 2: Comparison of changes in central 10º refraction after OrthoK lens wear in open eye condition post half an hour and post 2 hours to the baseline measurement. Error bars represent standard error of the mean.

Mean baseline PR at 25° and beyond both nasally and temporally was found to be -0.54 ± 1.68 D (mean ± SD) which increased to -1.29 ± 1.43 D (mean ± SD) post half an hour of lens wear and further increased to -1.62 ± 1.53 D (mean ± SD) post 2 hours lens wear. Statistical significance ($p < 0.01$) was seen for both duration of lens wear as compared to baseline (figure 3). Compared to baseline no significant changes were seen in peripheral astigmatism J180/J45 for both lens wear duration ($p > 0.05$).

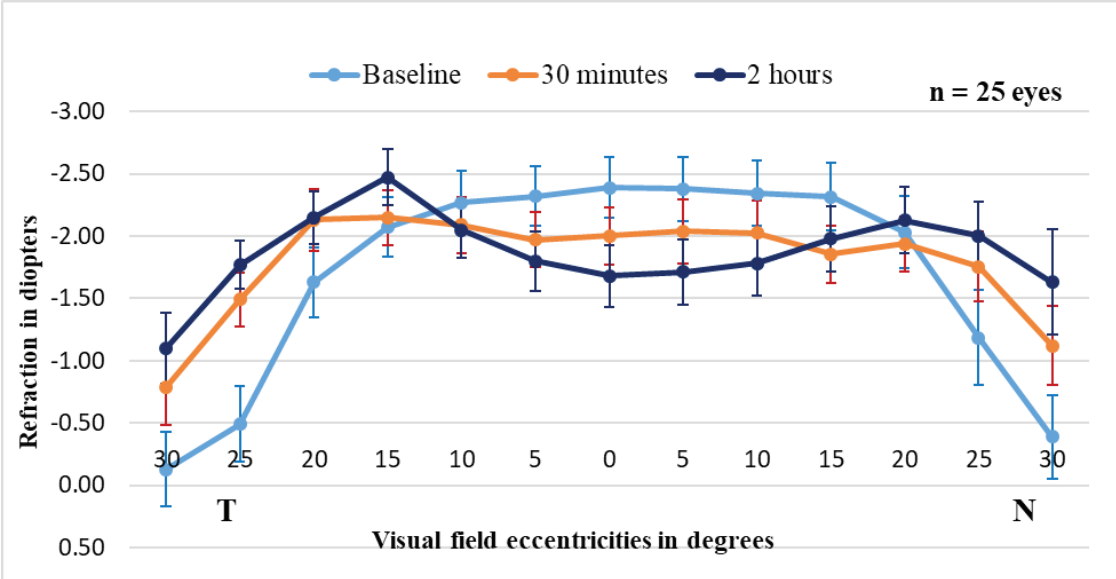

Figure 3: Comparison of peripheral refraction (M) changes after OrthoK lens wear in open eye condition post half an hour (indicated with orange line) and 2 hours (indicated with dark blue line) to the baseline measurement (indicated with a sky blue line). The letter 'T' denotes the temporal visual field and 'N' denotes the nasal visual field. Error bars represent standard error of the mean.

The unaided VA improved from mean 0.85 + 0.37 log (mean ± SD) at baseline to mean 0.49 + 0.35 log (mean ± SD) ($p < 0.01$) post half an hour of lens wear and mean 0.39 + 0.35 log (mean ± SD) ($p < 0.01$) after 2 hours of OrthoK lens wear. The VA post OrthoK lens wear displays better improvement with longer duration of lens wear as seen in figure 4.

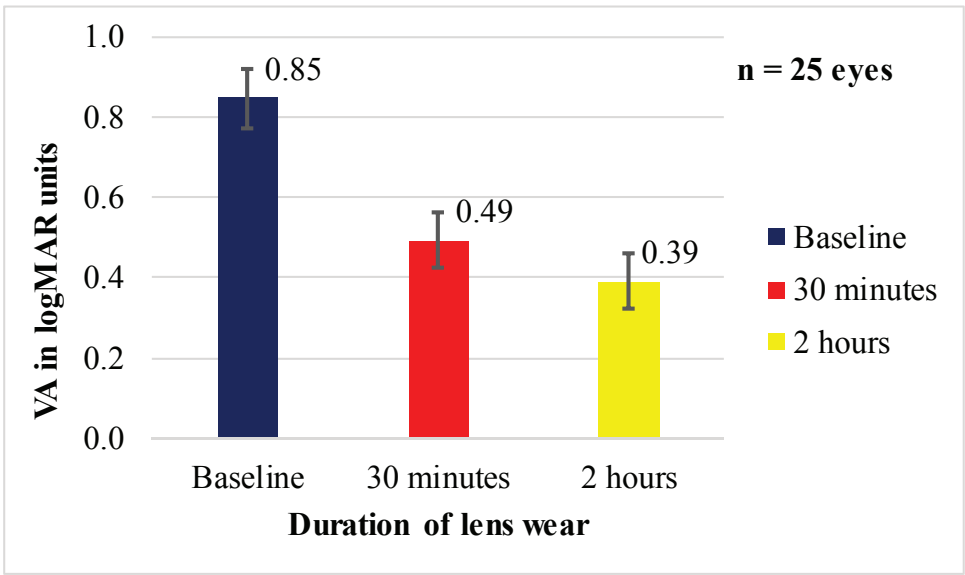

Figure 4: Comparison of changes in visual acuity after OrthoK lens wear in open eye condition post half an hour and post 2 hours to the baseline measurement. Error bars represent standard error of the mean.

Mean baseline ACP was 43.45 ± 1.34 D (mean ± SD) that reduced to mean 43.11 ± 1.37 D (mean ± SD) ($p < 0.01$) post half an hour of lens wear and a further reduction to mean 42.73 ± 1.34 D (mean ± SD) ($p < 0.01$) after 2 hours lens wear. A gradual decrease in ACP with longer duration in lens wear is displayed in figure 5.

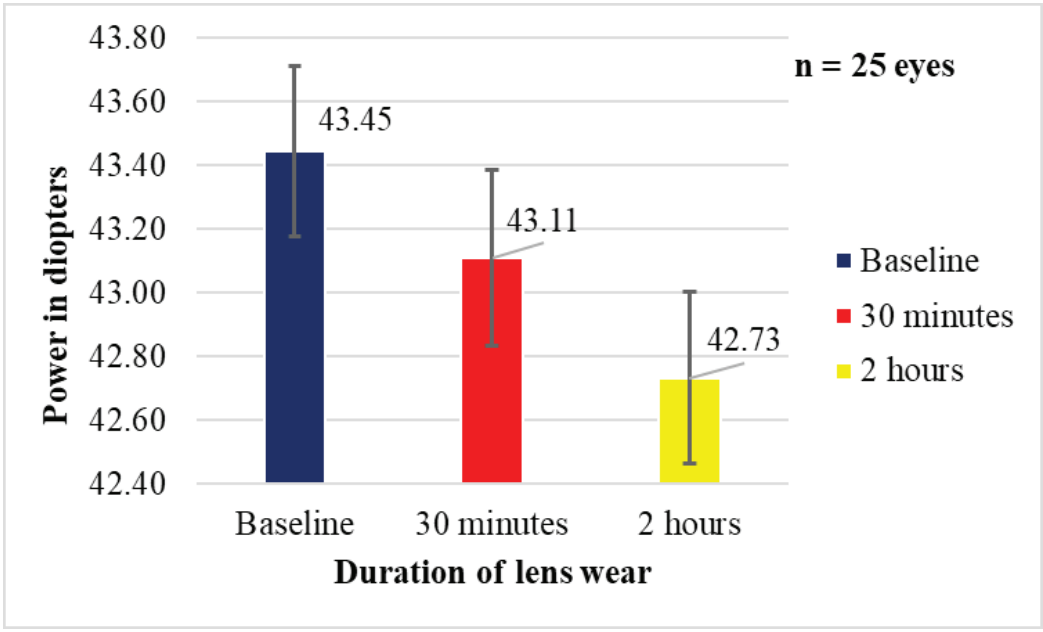

Figure 5: Comparison of changes in ACP after OrthoK lens wear in open eye condition post half an hour and post 2 hours to the baseline measurement. Error bars represent standard error of the mean.

Mean CCT recorded at baseline was 499.96 ± 35.93 µm (mean ± SD). Post half an hour of OrthoK lens wear a mean reduction of 1.72 ± 5.50 µm (mean ± SD) in CCT was seen as compared to baseline but was found to be not significant ($p > 0.05$). After 2 hours lens wear CCT further reduced by mean 14.92 ± 4.68 µm (mean ± SD) and was found to be statistically significant as compared to baseline ($p < 0.01$). Figure 6 displays a reduction in CCT with increased duration of lens wear.

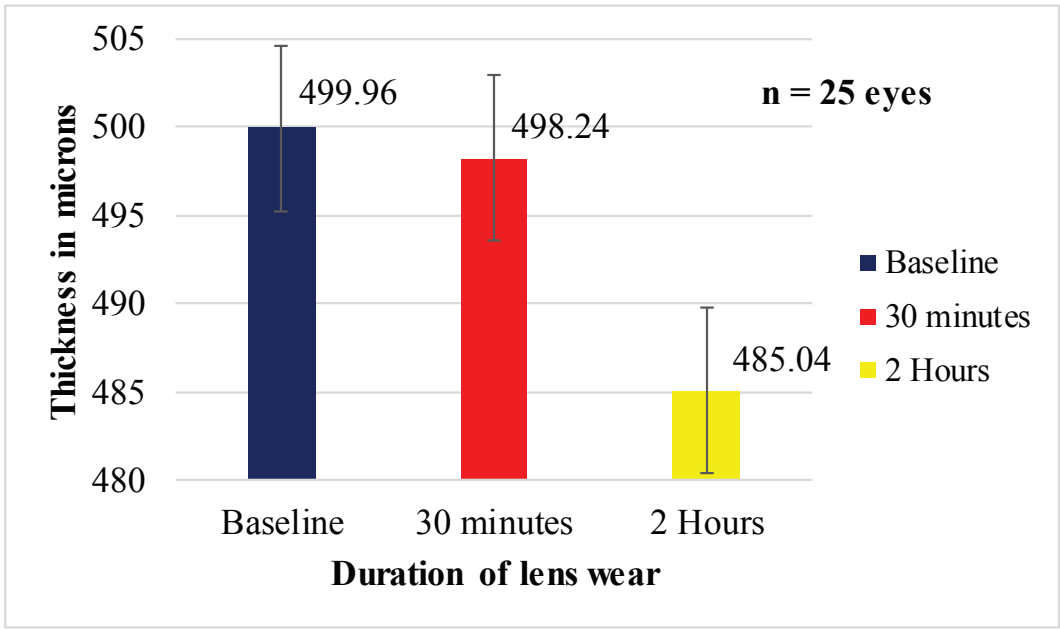

Figure 6: Comparison of changes in CCT after OrthoK lens wear in open eye condition post half an hour and post 2 hours to the baseline measurement. Error bars represent standard error of the mean.

Discussion

Ramkumar and Swarbrick [10] in 2003 studied corneal topography and VA changes post usage of OrthoK lenses worn in open eye condition. Their findings reported significant change in apical corneal flattening of -1.21 ± 0.52 D (mean ± SD) and improvement in uncorrected VA of -0.51 ± 0.25 log (mean ± SD) post 1 hour of lens wear as compared to baseline values. This study reported a similar flattening of the cornea with the difference between baseline ACP and post 2 hours lens wear values were -0.71 ± 0.23 D (mean ± SD). An improvement of 0.46 ± 0.28 log (mean ± SD) in uncorrected VA was also recorded post 2 hours lens wear which is again in agreement with the above-mentioned study. The possible mechanism of corneal flattening was attributed by the authors to the tear film forces acting below the contact lens surface thereby compressing the cornea.

Jayakumar and Swarbrick [11] in 2005 evaluated changes in apical corneal curvature, central corneal thickness, and uncorrected VA post 1 hour of open eye OrthoK lens wear in young adults. Their findings reported similar changes in apical corneal flattening of 0.15 ± 0.01 mm (mean ± SD) and improvement in uncorrected VA of 0.60 ± 0.28 log (mean ± SD) post 1 hour of lens wear as compared to baseline values. Statistical changes in CCT as compared to baseline values were reported to be 5.2 ± 2.0 µm (mean ± SD) post 1 hour of lens wear as compared to baseline values and were mostly at the epithelial level. This study reported a more substantial reduction of 14.92 ± 4.68 µm (mean ± SD) µm post 2 hours of open eye OrthoK lens wear. The reason can be attributed to the longer duration of 2 hours lens wear in this study versus 1-hour wear in the above-mentioned study.

Changes in PR post short term wear of OrthoK lenses has till date not been studied. The most relevant study was done by Kang and Swarbrick [6] in 2013 who monitored PR after 1, 4, 7, and 14 nights of overnight OrthoK lens wear. They concluded that the highest shift in central refraction and PR occurred after wearing lens for 1 night with the least changes observed between 7 and 14 nights of lens wear. This study reported that compared to the baseline mean refraction in central 10º of visual field reduced by -0.36 ± 0.26 D (mean ± SD) post 30 min lens wear and -0.63 ± 0.32 D (mean ± SD) post 2 hours lens wear and was statistically significant ($p < 0.01$) for both lens wear duration. Mean baseline PR at 25° and beyond both nasally and temporally was found to be -0.54 ± 1.68 D (mean ± SD) which increased to -1.29 ± 1.43 D (mean ± SD) post half an hour of lens wear and further increased to -1.62 ± 1.53 D (mean ± SD) post 2 hours lens wear. Statistical significance ($p < 0.01$) was seen for both duration of lens wear as compared to baseline. This study thus confirms rapid changes in corneal flattening and an increase in peripheral myopia after 2 hours of lens wear. Previous studies[1-7] have also concluded that peripheral increase in myopia refraction is an effective strategy to control myopia progression among children. The present study results will thus form the basis for a future longitudinal study where routine short term wear of OrthoK can be used as an alternative to overnight lens wear for myopia control.

Conclusion: Rapid changes in the cornea, peripheral refraction, and visual acuity are observed after half an hour of OrthoK lens wear with a steady increase in impact post 2 hours of lens wear. Further, a longitudinal study will be required to assess the role of short term OrthoK lens wear on myopia control.

Conflict of Interest: Nil

Source of Funding: Nil

Ethical Clearance: Approved

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