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Exploring The Role of Decentered Orthokeratology Lenses in Controlling Myopia: A Longitudinal Study

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ABSTRACT

Purpose: This study aimed to evaluate the impact of orthokeratology (OK) lens decentration on myopia control, focusing specifically on its effect on axial length (AL) growth in children. We compared the outcomes of centrated versus decentered OK lenses over a 12-month period.

Methods: In this retrospective study, 30 children (15 males, 15 females, mean age 9.3 ± 1.51 years) were included. Each child wore OK lenses with one eye fitted centrically and the other with decentered lenses for over 12 months. All participants had uncorrected visual acuity (UCVA) better than 0.1 logMAR and no significant ocular complications. We assessed refractive parameters, axial length growth, and myopia control efficiency, considering both the direction and degree of lens decentration.

Results: The average decentration distance in the decentered group was 0.73 ± 0.25 mm. Axial length growth was significantly slower in the decentered group (0.20 ± 0.24 mm per year) compared to the centrated group (0.29 ± 0.20 mm per year) ($p < 0.05$). The efficiency of myopia control, determined by the ratio of AL growth between the decentered and centrated eyes, was 0.69 ± 0.50 for the temporal decentration group and 0.75 ± 0.52 for the other direction decentration group, showing no significant directional effect ($p > 0.05$). No significant correlation was observed between the degree of decentration and myopia control efficiency within the temporal decentration group.

Conclusions: This study suggests that mild decentration of OK lenses may be more effective in slowing myopia progression than centration. There were no significant differences between temporal and other direction decentration, and no strong correlation between the degree of decentration and myopia control efficiency. These findings indicate that even modest lens decentration could be a promising strategy for myopia management in clinical practice..

Keywords: *Orthokeratology, Myopia control, Axial length growth, Lens decentration, Myopia progression, Children*

1. INTRODUCTION

Myopia, or near sightedness, is a refractive error that occurs when the eye elongates, causing light to focus in front of the retina, resulting in blurred distant vision. The prevalence of myopia has increased significantly worldwide, with estimates suggesting that by 2050, nearly half of the global population will be affected by this condition (Morgan et al., 2012). In East Asia, the prevalence is particularly high, with up to 80-90% of young adults affected by myopia (Lin et al., 2004). This rise in myopia prevalence is concerning, as high levels of myopia are associated with an increased risk of developing serious ocular complications, including retinal detachment, cataracts, glaucoma, and myopic maculopathy (Lim et al., 2013). Given the long-term health risks associated with myopia, effective strategies for its prevention and control are urgently needed

Orthokeratology (OK) lenses, or corneal reshaping contact lenses, have emerged as one of the most popular and effective treatments for controlling myopia progression, particularly in children and adolescents. OK lenses are worn overnight to temporarily reshape the cornea, allowing for the correction of refractive errors without the need for daytime spectacles or contact lenses (Cho & Cheung, 2012). Studies have demonstrated that OK lenses can slow axial length (AL) growth, a key factor contributing to myopia progression, and provide effective myopia control (Walline et al., 2009). In addition to. refractive correction, OK lenses have been shown to have a protective effect against the development of high myopia, making them a valuable tool in myopia management (Swarbrick, 2006)

The mechanism by which OK lenses control myopia is not yet fully understood, but it is believed that the lenses redistribute corneal epithelial cells during overnight wear, leading to a flattening of the central cornea and a reduction in myopic refractive error (Kollbaum et al., 2013). Several factors may influence the success of OK lenses in controlling myopia progression, including the design and fit of the lenses, the wear time, and the treatment zone's size and position. One of the key aspects of OK lens design is the **centring** of the lens treatment zone over the cornea, which is assumed to provide optimal reshaping of the central cornea. However, despite efforts to achieve perfect centration, it is not uncommon for the treatment zone to become slightly **decentered** during lens wear (Tang et al., 2018).

Lens decentration refers to the misalignment of the treatment zone of the OK lens relative to the corneal apex or the pupil center. While traditionally, OK lenses are designed to fit centrally over the cornea for optimal visual outcomes, decentration could potentially influence the efficacy of myopia control. Previous studies have suggested that decentration might have a differential effect on the cornea and the rate of myopia progression. For instance, some evidence suggests that **temporal decentration** (where the treatment zone is shifted temporally relative to the pupil center) may enhance the effectiveness of myopia control, possibly due to altered pressure distribution on the corneal surface (Liu et al., 2019; Zhang et al., 2020). Other research has shown that decentration in different directions (e.g., inferior or superior) may result in varied effects on axial length growth (Li et al., 2016). However, the relationship between the direction and degree of decentration and myopia control remains unclear.

Despite these findings, there is still limited consensus on how decentration influences myopia progression in the long term. Most studies on OK lens decentration have been small-scale, cross-sectional, or observational, often without adequately controlling for other factors such as lens fit, corneal topography, and individual patient characteristics (Cheng et al., 2021). Moreover, while some studies have suggested that lens decentration may provide enhanced myopia control, the effect of different decentration distances and directions on treatment efficacy has yet to be thoroughly explored in a controlled study design.

Given these gaps in the literature, the current study aims to investigate the effect of decentration in OK lenses on myopia control, focusing on whether eyes with decentered treatment zones experience slower myopia progression compared to eyes with centrally fitted lenses. Specifically, the objectives of this study are:

1. To compare the axial length (AL) growth between eyes with decentered OK lenses and eyes with centrated OK lenses.
2. To assess whether the direction of decentration (temporal vs. other directions) influences the efficiency of myopia control.
3. To explore the relationship between the degree of decentration and the rate of axial length growth.

We hypothesize that OK lenses with a decentered treatment zone may slow myopia progression more effectively than centrated lenses, as the redistribution of corneal forces could lead to differential reshaping of the cornea and a more effective management of axial elongation.

2. METHODS

This study retrospectively analyzed 30 OK lens wearers who were selected from a pool of more than 100 cases at our hospital. The inclusion criteria were:

- Both eyes were fitted with OK lenses, with one eye showing centration and the other showing off-center decentration for more than 12 months.
- The uncorrected visual acuity (UCVA) in both eyes was better than 0.1 LogMAR.
- There were no signs of tropia, significant changes in the angle kappa, or any complications such as glare or diplopia during the follow-up period.

The participants' baseline parameters were measured, including equivalent spherical power, astigmatism, keratometry (K) values (flat K, steep K), and lens diameter. We compared the effects of decentration versus centration in terms of myopia control.

3. RESULTS

This study aimed to investigate the impact of decentration in orthokeratology (OK) lenses on myopia control by comparing the axial length growth between eyes with decentered and centrated lenses. The data were collected from 30 patients (15 males and 15 females), with a mean age of 9.3 ± 1.51 years. During the study period, each patient wore OK lenses in both eyes, with one eye showing centration (centrated group) and the other showing decentration (decentered group) for more than 12 months.

Baseline Characteristics

At baseline, no significant differences were found between the centrated and decentered groups in terms of key refractive and corneal parameters. These included the equivalent spherical power, astigmatism, e-value, flat K, steep K, lens diameter, and toric power. These similarities ensured that the two groups were comparable and helped to isolate the effect of decentration on myopia progression.

Decentration Distance

In the decentered group, the mean distance of decentration was 0.73 ± 0.25 mm. This suggests a mild but consistent shift in the treatment zone of the lens relative to the corneal center. In comparison, the centrated group had no decentration (i.e., the treatment zone was perfectly aligned with the corneal apex).

Axial Length Growth

The primary measure of myopia control in this study was the growth of axial length (AL) per year, a crucial factor associated with myopia progression. The data showed that the **decentered group** exhibited a slower rate of axial length growth compared to the **centrated group**. Specifically:

- **OK-Lens-Centered Group:** The average axial length growth was 0.29 ± 0.20 mm per year.
- **OK-Lens-Decentered Group:** The average axial length growth was significantly slower at 0.20 ± 0.24 mm per year.

This difference in axial length growth was statistically significant (**$p < 0.05$**), indicating that lens decentration may be more effective at slowing myopia progression compared to centration.

Efficiency of Myopia Control

To assess the relative effectiveness of myopia control, we calculated the **efficiency of myopia control** for each group. This was defined as the ratio of axial length growth in the decentered eye compared to the centrated eye. This analysis also took into account the direction of decentration (temporal vs. other directions). The efficiency was found to be:

- **Temporal Decentration Group (20 eyes):** The efficiency of myopia control was 0.69 ± 0.50, meaning that the decentered eyes showed 69% of the axial growth rate of the centrated eyes.
- **Other Direction Decentration Group (10 eyes):** The efficiency of myopia control was 0.75 ± 0.52, indicating that the eyes with decentration in other directions showed 75% of the axial growth rate of the centrated eyes.

Interestingly, **no significant difference** was observed between the two subgroups (temporal vs. other direction decentration) with respect to the efficiency of myopia control (**$p > 0.05$**). This suggests that, in our study, the direction of decentration did not significantly affect the effectiveness of myopia control.

Degree of Decentration and Myopia Control

Finally, we analyzed whether the **degree of decentration** had any correlation with the **efficiency of myopia control** within the temporal decentration group. However, no significant correlation was found (**$p > 0.05$**), indicating that the degree of misalignment between the treatment zone and the corneal apex did not significantly influence the treatment's effectiveness.

Summary of Key Findings

To better illustrate the key findings of this study, we present the data in the table below:

Table 1: Summary of Key Results

Parameter	**OK-Lens-Centered Group**	**OK-Lens-Decentered Group**	**p-Value**
Number of Eyes (n)	30 (15 male, 15 female)	30 (15 male, 15 female)	-
Mean Age (Years)	9.3 ± 1.51	9.3 ± 1.51	-
Axial Length Growth (mm/year)	0.29 ± 0.20	0.20 ± 0.24	< 0.05
Efficiency of Myopia Control (AL Growth Ratio)	-	0.69 ± 0.50 (temporal) 0.75 ± 0.52 (other direction)	> 0.05
Decentration Distance (mm)	0	0.73 ± 0.25	-
Corneal Parameters (e-value, K, astigmatism, etc.)	No significant difference	No significant difference	> 0.05
Degree of Decentration and Efficiency Correlation (Temporal Group)	-	No significant correlation	> 0.05

Interpretation of Findings

1. **Axial Length Growth:** The significant difference in axial length growth between the centrated and decentered eyes (**$p < 0.05$**) suggests that decentration of OK lenses may offer a more effective method for slowing myopia progression. Slower axial elongation is a key determinant of myopia control, and the decentered lenses appear to have a positive influence in this regard.
2. **Efficiency of Myopia Control:** The efficiency of myopia control was found to be similar between the temporal and other direction decentration groups, indicating that the direction of decentration does not significantly alter the effectiveness of myopia control in this study. This is an important finding, as it suggests that moderate decentration, regardless of direction, can be beneficial for myopia management.
3. **Degree of Decentration:** The lack of correlation between the degree of decentration and the efficiency of myopia control within the temporal decentration group suggests that the amount of decentration may not be as critical to the treatment's success as previously thought. This finding is important because it implies that even modest decentration may still be effective in slowing myopia progression.

4. DISCUSSION

The primary objective of this study was to investigate the effect of orthokeratology (OK) lens decentration on myopia control, specifically focusing on axial length (AL) growth as an indicator of myopia progression. Our findings suggest that OK lenses with a decentered treatment zone may be more effective in slowing the progression of myopia compared to centrated lenses, with significant differences in axial length growth observed between the two groups. These results provide valuable insights into the role of lens decentration in myopia management, which has been a subject of debate in recent years.

Effect of Decentration on Myopia Control

In our study, the decentered group exhibited a significantly slower rate of axial length growth (0.20 ± 0.24 mm per year) compared to the centrated group (0.29 ± 0.20 mm per year). This difference was statistically significant (**$p < 0.05$**), suggesting that OK lens decentration may be more effective in controlling myopia progression. Previous studies have shown that lens decentration can alter the distribution of corneal reshaping forces, potentially resulting in different corneal topographies that affect axial elongation (Zhang et al., 2019).

The mechanism by which decentration might influence myopia control is not entirely clear, but several hypotheses exist. One theory suggests that decentration leads to a shift in the distribution of peripheral defocus, which is thought to play a key role in myopia progression (Sherwin et al., 2014). In particular, temporal decentration may lead to a myopic shift in the peripheral retina, which could induce compensatory eye growth in an attempt to balance the retinal defocus. However, the relationship between the direction and degree of decentration and myopia control remains complex and may vary across individuals.

Comparison of Directional Decentration: Temporal vs. Other Directions

In our study, we also examined the efficiency of myopia control based on the direction of decentration. We found no significant difference in myopia control efficiency between eyes with temporal decentration (0.69 ± 0.50) and eyes with decentration in other directions (0.75 ± 0.52). This finding is consistent with some previous studies that have suggested that the direction of decentration might not significantly affect the overall effectiveness of myopia control (Cheng et al., 2021; Liu et al., 2020). The lack of a significant directional effect might indicate that the primary factor contributing to myopia control is the presence of decentration itself, rather than the precise direction of the shift.

However, the literature on this topic remains somewhat inconclusive. Some studies have suggested that temporal decentration may have a more pronounced effect on myopia control due to its influence on peripheral retinal defocus (Liu et al., 2019). Conversely, other studies have argued that decentration in any direction can be beneficial for myopia management, as long as it results in some degree of peripheral defocus (Zhao et al., 2017). Given the variability in results, further research is needed to fully understand how different directions of decentration may impact myopia progression.

Degree of Decentration and Myopia Control Efficiency

Interestingly, our study found no significant correlation between the **degree of decentration** and the **efficiency of myopia control** within the temporal decentration group. This suggests that even modest amounts of decentration may be effective in controlling myopia, which challenges the conventional notion that greater decentration leads to more significant effects. This result is consistent with a study by Li et al. (2016), which found that small degrees of decentration were still effective in slowing myopia progression. The findings from our study support the idea that **modest decentration** may be sufficient to achieve significant myopia control, which could have important implications for clinical practice.

In contrast, some studies have suggested that larger decentration distances are required to achieve optimal myopia control. For example, Zhao et al. (2018) showed that greater decentration in orthokeratology lenses produced better results in slowing axial length growth. The discrepancy between our findings and those of Zhao et al. (2018) may be due to differences in study design, patient population, or decentration thresholds. Nonetheless, our study suggests that modest amounts of decentration, in combination with other factors such as lens fit and wear time, may be sufficient to achieve significant benefits in myopia control.

Clinical Implications and Future Directions

Our findings have important clinical implications for the management of myopia in children and adolescents. If OK lens decentration can be demonstrated to reliably slow myopia progression, this could offer a more effective strategy for controlling myopia, particularly in cases where centration is difficult to achieve or maintain. Additionally, the results suggest that even a small degree of decentration may be beneficial, which could make orthokeratology more accessible and easier to manage in clinical settings.

However, while our study provides valuable insights, several limitations must be considered. First, our study was retrospective and observational in nature, which limits the ability to infer causality. A prospective, randomized controlled trial would provide more robust evidence regarding the effect of lens decentration on myopia control. Additionally, the degree of decentration was relatively modest in our study, and further research is needed to determine whether larger degrees of decentration might provide even more effective results. Moreover, other factors such as age, gender, lens design, and corneal topography may also influence myopia control and should be considered in future studies.

5. CONCLUSION

In conclusion, this study provides evidence that decentration of the OK lens treatment zone can be an effective strategy for myopia control, potentially offering better results than centrally fitted lenses. The results suggest that lens decentration may slow the progression of myopia by reducing axial length growth, and the direction of decentration does not appear to significantly affect the treatment's efficacy. Furthermore, the degree of decentration does not have a strong correlation with myopia control efficiency, suggesting that even a modest amount of decentration may have a beneficial impact. These findings support the idea that slight decentration could be incorporated as a viable strategy in orthokeratology for enhancing myopia control.

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