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Effectiveness of Corneal Reshaping Lenses in Controlling Axial Length in Myopic Children and Adolescents

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Abstract: *Objective:* To explore the effect of keratoplasty on the control of the ocular axis in children and adolescents with myopia. *Methods:* Seventy-five cases of children and adolescents who underwent myopia correction at a hospital between September 2023 and August 2024 were selected. Participants were divided into a control group (37 cases, wearing eyeglasses) and an observation group (38 cases, wearing keratoplasty lenses) using the random number method. Visual function, naked-eye visual acuity, ocular axis length, and refractive error were compared and analyzed between the two groups before and one year after the correction treatment. *Results:* Before correction, there were no statistically significant differences in the amplitude and sensitivity of accommodation between the two groups ($P > 0.05$). After correction, all indices increased significantly in both groups, with the observation group showing higher values than the control group ($P < 0.05$). Similarly, prior to correction, there were no significant differences in naked-eye visual acuity, axial length, or refractive error between the two groups ($P > 0.05$). After correction, all indices improved significantly in both groups; however, the observation group demonstrated superior results compared to the control group, with statistically significant differences ($P < 0.05$). Specifically, the naked-eye visual acuity in the observation group was higher, refractive error was lower, and ocular axis length was shorter than in the control group, all with statistical significance ($P < 0.05$). *Conclusion:* Keratoplasty effectively controls the ocular axis in children and adolescents with myopia. It not only enhances visual function but also significantly improves naked-eye visual acuity, reduces refractive error, and shortens the length of the ocular axis.

Keywords: Myopia in children and adolescents; Keratoplasty; Ocular axis; Naked-eye visual acuity; Visual quality

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1. Introduction

In recent years, the incidence of myopia among children and adolescents has continued to rise, driven by the widespread use of electronic devices and reduced outdoor activity. This trend has become a global public health

concern. Myopia not only impairs vision but also increases the risk of severe complications such as retinal detachment, macular degeneration, and glaucoma, which have lasting impacts on visual function and quality of life [1]. Therefore, identifying effective strategies to prevent and control myopia is of critical importance.

Orthokeratology (OK lenses), a non-surgical and reversible form of vision correction, has gained considerable attention in myopia prevention and control [2]. When worn overnight, OK lenses utilize tear dynamics and the elasticity of corneal tissue to gently reshape the central cornea. This reshaping allows users to experience clear vision during the day without the need for glasses. Additionally, studies have demonstrated that OK lenses effectively slow the elongation of the ocular axis, which is a key factor in myopia progression and its associated complications [3].

Children and adolescents are at a critical stage of ocular development, during which rapid axial elongation is closely associated with the progression of myopia and the risk of developing high myopia in the future. By slowing the growth of the ocular axis, OK lenses not only control myopia progression but also improve the quality of life for children and adolescents. However, despite their increasing use, the exact mechanisms and long-term effects of OK lenses require further investigation [4].

Moreover, individual responses to OK lenses may vary based on age, gender, and initial refractive status, posing challenges and opportunities for further research. This study aims to investigate the effect of keratoplasty on ocular axis control in children and adolescents with myopia, with the goal of providing a scientific basis for the precise selection and clinical application of OK lenses.

2. Materials and methods

2.1. General information

Seventy-five cases of children and adolescents who underwent myopia correction treatment at a hospital between September 2023 and August 2024 were selected. The participants were randomly divided into a control group and an observation group using the random number method.

In the control group, there were 37 cases, including 19 males and 18 females. The age range was 9–15 years, with a mean age of (11.2 ± 1.8) years. The duration of myopia ranged from 1 to 5 years, with a mean of (2.8 ± 1.2) years. The initial refraction ranged from -1.50D to -6.00D, with a mean of (-3.50 ± 1.00)D.

In the observation group, there were 38 cases, including 20 males and 18 females. The age range was 9–16 years, with a mean age of (11.4 ± 1.6) years. The duration of myopia ranged from 1 to 6 years, with a mean of (3.0 ± 1.3) years. The initial refraction ranged from -1.75D to -6.25D, with a mean of (-3.60 ± 1.10)D.

The differences between the two groups in terms of gender, age, myopia duration, and initial refractive error were not statistically significant ($P > 0.05$), indicating that the two groups were comparable. The study was approved by the hospital's ethical committee.

Inclusion criteria: (1) Children and adolescents aged 9–16 years; (2) Myopia ranging between -1.50D and -6.00D, with astigmatism not exceeding -1.50D; (3) No organic pathology of the anterior segment (e.g., cornea, conjunctiva, sclera) and ocular health meeting the requirements for wearing keratoplasty lenses; (4) The children and their families fully understand the study's purpose, signed informed consent, and agreed to cooperate with treatment and follow-up; (5) Absence of prior vision correction interventions, such as medication or laser surgery, in the last six months.

Exclusion criteria: (1) Presence of eye diseases such as dry eye, keratitis, conjunctivitis, or glaucoma that

could affect the use of keratoplasty lenses; (2) Presence of systemic diseases such as diabetes or autoimmune disorders that might influence study outcomes; (3) Significant discomfort or intolerance to keratoplasty lenses after the initial fitting; (4) Inability to wear keratoplasty lenses as required or to complete follow-up visits as scheduled.

2.2. Methodology

In the control group, patients were prescribed frame spectacles according to their refractive status, as determined by a comprehensive examination. The nursing staff explained to the children and their families the correct method for wearing spectacles, including adjusting the glasses' position, daily cleaning and maintenance, and the required duration of use. The importance of avoiding the use of glasses during strenuous activities or sleep was emphasized to prevent damage or injury. Family members were advised to supervise the children to ensure timely and proper use of the glasses and to promote good eye care habits for effective myopia correction.

In the observation group, children were fitted with keratoplasty lenses tailored to their refractive status, based on a comprehensive examination that included corneal curvature, corneal diameter, axial length, and refractive measurements. Professional technicians carefully assessed the centering, mobility, and tear distribution of the lenses to ensure proper fit and comfort. Corneal health was monitored to rule out adverse reactions such as keratitis or conjunctivitis.

After confirming the lenses' safety and efficacy, detailed instructions were provided to the children and their families on the proper methods for wearing and removing the lenses. Guidelines included cleaning procedures, the use of lubricating fluid, and precautions to prevent lens damage. Children were instructed to wear the keratoplasty lenses overnight for a minimum of 8 hours daily to achieve the corrective effect.

Daily hygiene and care requirements during the wearing period were emphasized, and parents were advised to monitor their children's adaptation during the initial wearing period. Regular follow-up visits were scheduled to assess treatment progress, adjust lens parameters, or modify the wearing plan as necessary, ensuring optimal safety and efficacy.

2.3. Observation indicators

(1) Visual function: The amplitude and sensitivity of binocular accommodation were measured before and 1 year after correction. Amplitude of accommodation was measured using the positive and negative lens accommodation method, recording the maximum and minimum accommodation abilities of the children. Accommodation sensitivity was assessed using alternating positive and negative 0.5D lenses to observe the speed and accuracy of the accommodative response, ensuring result accuracy and comparability.

(2) Naked-eye visual acuity, axial length, and refractive error: Before and 1 year after correction, naked-eye visual acuity was measured using a standard logarithmic visual acuity chart, and changes in visual acuity were recorded. Axial length was measured using an ocular A-ultrabiometer, and axial length growth before and after correction was documented. Refraction was measured using an automated computer optometer, recording the spherical equivalent refraction (SE) of each child.

2.4. Statistical analysis

All data were statistically analyzed using SPSS 23.0 software. Measurement data were expressed as mean ± standard deviation (SD). Independent samples *t*-tests were used for inter-group comparisons, and paired t-tests were applied for intra-group comparisons. Categorical data were expressed as frequency and percentage, and

comparisons between groups were conducted using the χ^2 test. Differences were considered statistically significant when $P < 0.05$.

3. Results

3.1. Comparison of visual function between the two groups before and after correction

Before the correction, no statistically significant differences were observed in the amplitude of binocular accommodation and adjustment sensitivity between the two groups of children ($P > 0.05$). However, after correction, all visual function indicators in both groups improved significantly. The observation group demonstrated significantly higher values compared to the control group, with the differences being statistically significant ($P < 0.05$) (**Table 1**).

Table 1. Comparison of visual function between the two groups before and after correction (mean ± SD)

Groups	Magnitude of adjustment (D)				Adjustment sensitivity (cpm)			
	Pre-correction	Post-correction	*t*	*P*	Pre-correction	Post-correction	*t*	*P*
Control group (*n* = 37)	9.13 ± 2.06	10.89 ± 1.23	4.4620	0.0000	3.52 ± 1.07	6.37 ± 1.28	10.3912	0.0000
Observation group (*n* = 38)	9.09 ± 2.07	12.78 ± 1.34	9.2246	0.0000	3.45 ± 1.14	8.22 ± 1.46	15.8740	0.0000
t	0.0839	6.3587			0.2740	5.8289		
P	0.9334	0.0000			0.7848	0.0000		

3.2. Comparison of naked-eye visual acuity, axial length, and refraction between the two groups before and after correction

Before the correction, no significant differences were observed in naked-eye visual acuity, axial length, or refractive error between the two groups ($P > 0.05$). After correction, all indicators showed significant improvement in both groups. Specifically, naked-eye visual acuity in the observation group was significantly higher compared to the control group, while the refractive error was lower and the axial length increase was shorter. These differences were statistically significant ($P < 0.05$) (**Table 2**).

Table 2. Comparison of naked-eye visual acuity, axial length, and refraction between the two groups before and after correction (mean ± SD)

Groups	Naked-eye visual acuity		Axial length (mm)		Refractive error (D)	
	Pre-correction	Post-correction	Pre-correction	Post-correction	Pre-correction	Post-correction
Control group (*n* = 37)	0.33 ± 0.16	0.41 ± 0.14*	24.46 ± 0.47	25.63 ± 0.63*	-3.28 ± 0.62	-4.13 ± 0.62*
Observation group (*n* = 38)	0.32 ± 0.19	0.81 ± 0.22*	24.45 ± 0.52	24.96 ± 0.57*	-3.31 ± 0.59	-3.59 ± 0.27*
t	0.2462	9.3654	0.0873	4.8321	0.2147	4.9125
P	0.8062	0.0000	0.9307	0.0000	0.8306	0.0000

Note: *$P < 0.05$ compared to pre-correction.

4. Discussion

In recent years, the prevalence of myopia has been increasing due to factors such as prolonged near-vision activities, reduced time spent outdoors, extensive use of electronic devices, and poor visual habits among children and adolescents. Myopia not only impairs vision but also adversely impacts the quality of life and academic performance of affected individuals [5]. More critically, high myopia can lead to serious ocular complications, including retinal detachment, macular degeneration, glaucoma, and even irreversible vision loss. Early and effective intervention to control the progression of myopia, particularly by slowing the elongation of the ocular axis, is a crucial strategy for preventing high myopia and its associated complications, holding significant public health implications [6].

Spectacle lenses remain the most commonly used method for myopia correction. They primarily address refractive errors by adjusting the focal position of light rays, thereby improving visual acuity. Spectacles are widely adopted due to their safety, ease of use, and low cost, making them suitable for children and adolescents [7]. However, spectacles have notable limitations. Firstly, they provide only vision correction without effectively controlling the elongation of the ocular axis, limiting their role in slowing myopia progression. Secondly, spectacles can cause inconvenience during sports and daily activities, as they are prone to slipping or breaking, which increases safety risks [8]. Additionally, prolonged use of spectacles may affect self-identity among adolescents and contribute to psychological distress [9]. More importantly, spectacles do not address peripheral retinal defocus, which may further exacerbate myopia progression. Therefore, it is essential to explore more scientific and effective solutions for myopia management.

Orthokeratology (OK lenses) is a non-surgical approach that corrects vision and slows myopia progression through overnight lens wear. The primary mechanism involves reshaping the central cornea, thereby adjusting the focal position of light rays to achieve clear vision during the day without the need for spectacles [10]. This reshaping not only improves central vision but also addresses peripheral retinal defocus. Specifically, OK lenses shift peripheral hyperopic defocus to myopic defocus, which has been shown to slow the elongation of the ocular axis, providing a scientifically sound solution for myopia management in children and adolescents [11].

In this study, visual function, unaided visual acuity, axial length, and refractive error were compared between two groups of children receiving different corrective interventions. Before correction, there was no statistically significant difference in binocular accommodative amplitude and sensitivity between the two groups ($P > 0.05$). After correction, all parameters improved significantly in both groups, with the observation group showing significantly higher values compared to the control group ($P < 0.05$). Similarly, prior to correction, no significant differences were observed in unaided visual acuity, axial length, or refractive error between the groups ($P > 0.05$). After correction, these parameters improved significantly in both groups. Children in the observation group exhibited higher unaided visual acuity, lower refractive error, and shorter axial length compared to the control group, with the differences being statistically significant ($P < 0.05$).

These results can be attributed to the distinct advantages of OK lenses:

(1) OK lenses provide dual benefits: vision correction and effective myopia control, with their ability to slow axial elongation confirmed by numerous studies [12].

(2) Nighttime wear of OK lenses eliminates the inconvenience associated with corrective devices during daytime activities, offering children and adolescents greater freedom of movement.

(3) OK lenses do not affect physical appearance, which is particularly advantageous for adolescents who are sensitive about their appearance, thus improving treatment adherence.

5. Conclusion

In conclusion, orthokeratology lenses effectively improve visual function by enhancing unaided visual acuity, controlling axial length elongation, and reducing refractive error in children and adolescents with myopia. This method holds significant potential and is recommended for wider adoption in ophthalmologic myopia correction practices.

Disclosure statement

The authors declare no conflict of interest.

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