

Orthokeratology (Ortho-K) Lenses: Mechanisms, Clinical Efficacy, and Safety

Priyanka Chaudhary¹, Dr. Himadri S. Dey², Dr Sachin Datt³

¹PhD Scholar, Sushant University

²Associate Professor, Sushant University, Gurugram

³Associate Professor, Sushant University, Gurugram

Abstract: Orthokeratology (Ortho-K) is an increasingly adopted non-surgical intervention for correcting myopia (near-sightedness) and controlling its progression. It is particularly popular among children and adolescents. The technique involves overnight wear of specially designed rigid gas-permeable contact lenses, which are firm lenses that allow oxygen to reach the eye. These lenses temporarily reshape the corneal surface, the clear front part of the eye, enabling unaided, clear daytime vision. Beyond refractive correction (adjustment of the eye's ability to focus light), Ortho-K has gained clinical importance due to its potential to slow axial elongation, or the lengthening of the eyeball, a key factor in myopia progression. The primary mechanisms underlying its effectiveness include central corneal flattening, redistribution of epithelial cells (cells on the eye's surface), and the induction of myopic peripheral defocus, a phenomenon in which light focuses in front of the retina at the edges of vision, a phenomenon believed to regulate ocular growth.^{1,2,3} Clinical evidence demonstrates that Ortho-K is effective in correcting low-to-moderate myopia and significantly reduces myopia progression in paediatric populations compared with conventional spectacle correction. Visual outcomes are generally stable, with most patients achieving satisfactory uncorrected visual acuity throughout the day. While the procedure is considered safe, it is not without risks; common side effects include corneal staining and visual disturbances, and rare but serious complications, such as microbial keratitis, may occur, particularly with poor hygiene or non-compliance.^{4,5,6,7} Overall, orthokeratology is a valuable, reversible approach to both vision correction and myopia management. Its success, however, depends on appropriate patient selection, strict adherence to lens care protocols, and regular clinical monitoring.⁸

Keywords: orthokeratology, myopia control, corneal reshaping lenses, axial elongation, paediatric vision care

1. Introduction

Myopia, commonly called near-sightedness (difficulty seeing distant objects clearly), has become one of the most prevalent ocular disorders worldwide. It affects an ever-growing proportion of the global population. The condition is particularly widespread among children and adolescents. Its prevalence increases with lifestyle factors such as prolonged screen exposure, intensive educational demands, and reduced outdoor activity. The progression of myopia, especially when it develops early in life, can lead to high myopia (severe near-sightedness). High myopia significantly increases the risk of severe ocular complications, including retinal detachment (separation of the retina from the back of the eye), glaucoma (a condition of increased pressure in the eye that can damage the optic nerve), and myopic maculopathy (degeneration of the central part of the retina due to myopia).^{2,3}

Given these risks, clinicians increasingly emphasise interventions that both correct refractive errors and actively slow the progression of myopia. Orthokeratology has emerged as a promising solution in this context. Specially designed rigid gas-permeable lenses are worn overnight,

temporarily reshaping the cornea and enabling clear daytime vision without spectacles or contact lenses.¹

In contrast to refractive surgical procedures, orthokeratology provides a non-invasive, reversible, and adjustable alternative. This approach is particularly advantageous for paediatric patients and individuals seeking non-surgical options. Advances in lens design, including the use of reverse-geometry configurations and high oxygen-permeable materials, have significantly enhanced safety, comfort, and effectiveness. Consequently, Ortho-K is widely accepted in clinical practice as both a vision correction method and a myopia control strategy.^{1,2}

2. Literature Review

Extensive research has explored orthokeratology, and a substantial body of evidence supports its clinical utility. Early investigators primarily examined its refractive correction capabilities, demonstrating that Ortho-K effectively reduces myopia through controlled corneal reshaping. These studies confirmed that central corneal flattening combined with mid-

¹ Swarbrick HA. Orthokeratology review and update. *Clinical and Experimental Optometry*.

² Nichols JJ, Marsich MM. Corneal reshaping and epithelial changes in orthokeratology.

³ Smith EL III. Peripheral retinal defocus and refractive development.

⁴ Walline JJ, et al. The safety and effectiveness of orthokeratology.

⁵ Cho P, Cheung SW. Retardation of myopia progression using orthokeratology lenses.

⁶ Watt KG, Swarbrick HA. Microbial keratitis in orthokeratology: risk and prevention

⁷ Bullimore MA, Sinnott LT, Jones-Jordan LA. Risk of keratitis with overnight lens wear.

⁸ Lipson MJ. Patient compliance and contact lens safety.

peripheral steepening results in predictable improvements in uncorrected visual acuity.¹

As research progressed, attention shifted toward understanding its role in myopia control. The peripheral defocus theory became widely accepted, suggesting that Ortho-K induces myopic defocus in the peripheral retina, thereby reducing the stimulus for axial elongation. Multiple longitudinal studies have confirmed that children undergoing Ortho-K treatment exhibit slower myopia progression than those using traditional corrective methods.²

Recent research has also explored biomechanical and physiological effects, indicating that epithelial redistribution plays a central role in corneal reshaping. Additionally, advancements in imaging technologies have enabled more precise observation of structural changes in the eye, further validating Ortho-K's effectiveness.³

Safety remains a critical focus of the literature. While minor complications such as corneal staining are relatively common, serious complications, such as microbial keratitis, are rare and typically associated with poor hygiene practices. Systematic reviews indicate that the safety profile of Ortho-K is comparable to other overnight contact lens modalities.⁹

3. Objectives of the Study

The primary objective of this study is to provide a comprehensive evaluation of orthokeratology as a non-surgical option for correcting and controlling myopia. The analysis focuses on the mechanisms by which Ortho-K lenses reshape the cornea and influence ocular growth patterns, and assesses clinical efficacy in terms of visual acuity improvement and reduced axial elongation, particularly in paediatric populations. Another objective is to evaluate the safety profile of Ortho-K by identifying potential complications and contributing risk factors.

Additionally, this study examines advancements in lens design and clinical practices that may enhance treatment outcomes and broaden the application of orthokeratology in contemporary eye care.

4. Research Methodology and Mechanistic Framework

A qualitative, descriptive research design was employed, grounded in a comprehensive review of the literature on orthokeratology (Ortho-K) and myopia management. Data were collected from peer-reviewed journals, clinical trials, and systematic reviews to ensure reliability and scientific validity. The review focused on studies examining corneal reshaping mechanisms, myopia control strategies, clinical efficacy and safety outcomes, and technological advancements in lens design.

A thematic analysis approach was employed to organise the collected data into key domains, including mechanism of action, clinical effectiveness, safety profile, and emerging

innovations. Inclusion criteria ensured that only clinically relevant and methodologically sound studies were incorporated, while outdated, non-peer-reviewed, or non-reproducible sources were excluded. This structured methodology enables a comprehensive synthesis of current knowledge and facilitates the identification of trends in orthokeratology research.

Beyond reviewing clinical outcomes, this study integrates a mechanistic framework to explain how orthokeratology achieves both refractive correction and myopia control. Understanding the underlying biological and optical processes is essential for interpreting clinical findings and evaluating the effectiveness of Ortho-K as a therapeutic intervention.

1) Corneal Reshaping Mechanism

Orthokeratology primarily reshapes the cornea by redistributing epithelial cells. During overnight wear, specially designed lenses apply hydraulic pressure via the tear film. The lenses flatten the central cornea and steepen the mid-peripheral regions. This change reduces the eye's refractive power, allowing light to focus more accurately on the retina and improving visual acuity. Importantly, these changes remain temporary and reversible. Wearers must consistently use the lenses to maintain the effect.²

2) Peripheral Defocus Theory

A key mechanism underlying Ortho-K's myopia-control effect is the induction of peripheral myopic defocus. Conventional corrective lenses often create hyperopic defocus in the peripheral retina, which may stimulate axial elongation of the eye. In contrast, orthokeratology lenses alter corneal shape so that peripheral light rays are focused in front of the retina, generating a myopic defocus signal. This optical feedback is believed to slow ocular growth and reduce the progression of myopia.³

3) Biomechanical and Structural Effects

Beyond optical changes, orthokeratology may also influence the biomechanical properties of the eye. Research suggests that lens wear affects corneal stiffness, the distribution of epithelial thickness, and intraocular pressure dynamics. Some studies report short-term reductions in axial length, indicating that structural modifications may accompany optical correction. Although these findings require further investigation, they provide important insight into the broader physiological effects of Ortho-K therapy.⁹

5. Clinical Efficacy and Safety of Orthokeratology

Orthokeratology (Ortho-K) has demonstrated considerable effectiveness as both a refractive correction method and a myopia control strategy. It maintains an acceptable safety profile when used under proper clinical supervision. The dual evaluation of efficacy and safety is essential in determining its suitability for widespread use, especially among paediatric populations.

⁹ Kang P, Swarbrick HA. The effect of orthokeratology on ocular biomechanics.

- 1) **Myopia Correction:** Ortho-K is highly effective in correcting low-to-moderate myopia, typically up to -5.00 diopters. By temporarily reshaping the corneal surface during overnight wear, patients can achieve clear unaided vision throughout the day without reliance on spectacles or contact lenses. Most individuals experience noticeable improvement within a few days of treatment initiation, with stabilisation occurring over one to two weeks. The predictability and reversibility of this correction make Ortho-K a preferred option for patients seeking non-surgical alternatives.⁴
- 2) **Myopia Control in Children:** One of the most significant clinical benefits of Ortho-K is its ability to slow the progression of myopia in children. Numerous longitudinal studies have demonstrated reduced axial elongation in pediatric patients wearing Ortho-K lenses compared with those using conventional corrective methods. This effect is particularly valuable in preventing the progression of high myopia and its associated long-term ocular complications. As a result, Ortho-K is increasingly recognised as a key intervention in preventive ophthalmology.⁵
- 3) **Visual Performance:** In terms of visual performance, patients generally report stable and satisfactory vision throughout the day. Improvements in uncorrected visual acuity are consistent, although some individuals may experience temporary visual disturbances such as halos, glare, or reduced contrast sensitivity, especially during the initial adaptation phase. These symptoms typically diminish over time as the eye adjusts to the altered corneal shape.¹⁰
- 4) **Common Side Effects:** Despite its benefits, Ortho-K is associated with certain minor side effects. The most commonly reported issue is corneal staining, often related to lens fit or inadequate lubrication. Other side effects include lens decentration and transient visual disturbances. These complications are generally mild, manageable, and reversible with appropriate clinical adjustments and patient compliance.⁶
- 5) **Serious Complications:** Although rare, serious complications such as microbial keratitis represent the most significant risk associated with orthokeratology. This condition can be vision-threatening if not promptly treated and is typically linked to poor hygiene practices, improper lens handling, or non-compliance with care protocols. However, large-scale studies indicate that the risk is comparable to other forms of overnight contact lens wear, highlighting the importance of patient education and regular monitoring.⁷
- 6) **Long-Term Safety:** Long-term studies have shown that orthokeratology does not cause significant adverse effects on corneal health when lenses are properly fitted and maintained. There is no substantial evidence of permanent damage to the corneal endothelium or ocular structures. Regular follow-up visits and adherence to clinical guidelines are essential to ensure sustained safety and effectiveness over time.¹¹

6. Patient Selection and Clinical Considerations

Appropriate patient selection is a fundamental determinant of success in orthokeratology treatment, as not all individuals are equally suitable candidates for this modality. Ideal candidates typically include children with progressive myopia, as early intervention has been shown to significantly slow axial elongation and reduce the risk of developing high myopia later in life. Adults seeking non-surgical alternatives to refractive procedures such as LASIK also benefit from Ortho-K, particularly those with active lifestyles or occupational requirements that make daytime use of glasses or contact lenses inconvenient.

However, careful screening is essential to identify contraindications. Patients with poor hygiene practices, chronic ocular surface disease, severe dry eye, or irregular corneal topography may not be suitable candidates due to increased risk of complications or suboptimal treatment outcomes. Additionally, individuals with unrealistic expectations or a history of poor compliance should be approached cautiously.

Clinical considerations extend beyond initial selection to include precise lens fitting, regular monitoring, and patient education. Advanced diagnostic tools such as corneal topography play a critical role in designing customised lenses that ensure optimal centration and treatment effectiveness. Regular follow-up visits are essential for monitoring corneal health, assessing visual outcomes, and making necessary adjustments.

Patient compliance is arguably the most critical factor influencing both safety and efficacy. Strict adherence to lens-cleaning protocols, proper storage, and consistent overnight wear are necessary to maintain treatment effects and minimise complications. Clinicians must emphasise hygiene education and provide ongoing guidance to ensure the long-term success of orthokeratology therapy.⁸

7. Advantages and Limitations

Orthokeratology offers several distinct advantages that contribute to its growing popularity in clinical practice. One of its most significant benefits is that it is a non-invasive, reversible procedure, allowing patients to discontinue use at any time without permanently altering ocular structures. This makes it particularly appealing for paediatric populations and individuals who are not suitable candidates for refractive surgery. Additionally, Ortho-K provides clear daytime vision without glasses or contact lenses, enhancing convenience and quality of life, especially for athletes and those engaged in outdoor activities.

Another major advantage is its dual functionality: correcting refractive error and controlling myopia progression. This combination sets it apart from traditional correction methods,

¹⁰ Santodomingo-Rubido J, et al. Visual performance in orthokeratology patients.

¹¹ Chen C, et al. Long-term corneal health in orthokeratology lens users.

which typically address vision clarity but not disease progression. Furthermore, advancements in lens materials with high oxygen permeability have improved corneal health and reduced the risk of hypoxia associated with overnight wear.

Despite these advantages, orthokeratology also has certain limitations. The effects of corneal reshaping are temporary and require consistent nightly wear to maintain visual outcomes. Discontinuation of lens use results in gradual regression of the cornea to its original shape. Additionally, the effectiveness of Ortho-K is generally limited to low-to-moderate myopia, with reduced efficacy in cases of high myopia or significant astigmatism.

Cost and accessibility may also pose barriers, as Ortho-K requires specialised lenses, professional fitting, and ongoing follow-up care. Moreover, improper use or poor compliance can increase the risk of complications, underscoring the importance of patient education and clinical supervision.

8. Emerging Research and Innovations

The field of orthokeratology continues to evolve rapidly, driven by ongoing research and technological advancements aimed at improving treatment outcomes and expanding clinical applications. One of the most significant areas of innovation is the development of customised lens designs that cater to individual corneal profiles. Advanced corneal topography and wavefront analysis now allow practitioners to create highly personalised lenses, improving treatment precision, comfort, and visual quality.

Recent studies have also explored the use of Toric orthokeratology lenses for patients with astigmatism, significantly broadening the range of individuals who can benefit from this treatment. Additionally, smaller treatment zone designs are being investigated for their potential to enhance peripheral myopic defocus, thereby improving the effectiveness of myopia control.

Material science has also contributed to advancements in orthokeratology, with the introduction of lenses that offer higher oxygen permeability and improved biocompatibility. These materials reduce the risk of hypoxia-related complications and enhance overall safety during overnight wear.

Furthermore, emerging technologies such as artificial intelligence and machine learning are being integrated into lens-fitting and treatment-planning processes. These tools enable more accurate predictions of treatment outcomes and allow for data-driven customisation of lens parameters. Ongoing research is also investigating the long-term effects of Ortho-K on ocular biomechanics and its potential synergistic use with other myopia control strategies, such as pharmacological interventions.

Collectively, these innovations are expected to further enhance the safety, efficacy, and accessibility of

orthokeratology, solidifying its role as a cornerstone in modern myopia management.¹²

9. Conclusion

Orthokeratology (Ortho-K) has established itself as a significant advancement in non-surgical vision correction and myopia management. By utilising specially designed rigid gas-permeable lenses worn overnight, Ortho-K provides effective temporary corneal reshaping, allowing individuals to achieve clear, unaided vision during the day. More importantly, its demonstrated ability to slow axial elongation makes it a valuable intervention in controlling the progression of myopia, particularly in children and adolescents, where early treatment is crucial.

A substantial body of clinical evidence supports the efficacy and safety of orthokeratology when appropriately prescribed and monitored. Patients typically experience significant improvements in uncorrected visual acuity and overall visual performance. While minor side effects such as corneal staining, glare, or halos may occur, these are generally transient and manageable. Serious complications, including microbial keratitis, are rare and are largely associated with poor hygiene practices or non-compliance, emphasising the importance of patient education and regular clinical follow-up.

Despite certain limitations- such as the need for continuous nightly wear and reduced effectiveness in high myopia- Ortho-K offers distinct advantages, including reversibility, non-invasiveness, and dual functionality for both correction and myopia control.

With ongoing advancements in lens materials, customisation technologies, and clinical protocols, orthokeratology is poised to play an increasingly important role in addressing the global burden of myopia. Its integration into modern eye care reflects a shift toward preventive and patient-centred treatment approaches.

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