European Journal of Clinical Pharmacy
Print ISSN: 2385-409X **Online ISSN**: 3105-0409
Website: https://farmclin.com/

Original Research Article

Effectiveness of Atropine vs. Orthokeratology in Controlling Myopia Progression

Article History:

Received: 22-10-2025
Revised: 10-12-2025
Accepted: 20-12-2025
Published: 30-12-2025

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Abstract: ***Background:*** The global rise in childhood myopia has intensified the need for effective interventions that can slow its progression and prevent long-term ocular complications. ***Objective:*** To evaluate and compare the effectiveness of atropine and orthokeratology in controlling myopia progression in children. ***Methods:*** This retrospective comparative study was conducted at Alshifa Eye Trust Hospital Rawalpindi from June 2024 to June 2025 included 165 children diagnosed with progressive myopia who received either atropine therapy (n = 82) or orthokeratology lenses (n = 83). Clinical records were reviewed to collect baseline refractive error, axial length, age, gender, and follow-up data at 6 and 12 months. Outcomes measured included change in spherical equivalent refractive error, axial length elongation, and treatment-related complications. ***Results:*** At 12 months, children in the atropine group showed a smaller mean increase in axial length (0.22 ± 0.09 mm) compared with the orthokeratology group (0.32 ± 0.11 mm). Refractive progression was also lower in the atropine group (−0.38 ± 0.24 D) than in the orthokeratology group (−0.59 ± 0.28 D). Treatment-related complications were more frequently observed in the orthokeratology group (18.1%) compared with the atropine group (7.3%), primarily due to lens intolerance and mild superficial keratitis. ***Conclusion:*** Atropine demonstrated greater overall effectiveness in controlling myopia progression than orthokeratology over the 12-month period, with fewer complications and more consistent results across patients.

Keywords: Myopia progression, atropine, orthokeratology, axial length, refractive error

INTRODUCTION

Myopia has emerged as one of the most rapidly growing global public health concerns, with prevalence rates rising at an alarming pace, particularly in East and Southeast Asia. It is currently estimated that almost a half of the global population will be myopic and 10 percent of the global population will have high myopia with significant risk of permanent visual impairment [1]. This trend is reflective of a complicated association of genetic susceptibility, decreased out-of-doors activity, augmented near-work loads, and contemporary digital way of life that continually drive the visual system to axial elongation [2]. This has caused early and effective interventions in myopia control to become a priority in the pediatric ophthalmology to stop the long-term effects of myopia including retinal detachment, myopic maculopathy, glaucoma and early cataracts [3]. Myopia has become one of the most critical issues in the world ophthalmology, where the prevalence of myopia is increasing at a rate that reflects

the changing trend of modern lifestyles. The move towards more near-work activity such as more time in front of the screen, high academic achievement, and a lower proportion of time outdoors has had significant contributions to the occurrence of early-onset myopia in children [4]. It has been predicted that by the year 2050, nearly half a billion individuals will be myopic and nearly 1 billion will be having high myopia, which imposes a significant level of burden of visual impairment and economic pressure on health care systems [5]. The alarming aspect is not the refractive error, but the pathological outcomes of unregulated axial elongation, which is causing a major life-long risk of retinal detachment, staphyloma, myopic maculopathy, and choroidal thinning as well as glaucoma and other structural complications leading to the inability to recover the vision. The landscape of myopia control has been evolving greatly with response to this increasing crisis [6]. Two empirically supported, most commonly used, and widely accepted therapeutic modalities have been introduced to the body, including low-dose atropine and orthokeratology (ortho-k). Their popularity lies not only in the continuity of trial data, but also in their relatively safe profile and their appropriateness to be used in the long-term in children. In low doses (0.01%-0.05%), atropine eye drops have shown strong efficacy in slowing myopic progression through mechanisms of retinal neurotransmitter, scleral remodelling and muscarinic receptor regulation [7]. The high-dose atropine (1%) was first noted to have potent myopia control properties but was restricted by its serious adverse effects that included photophobia and blurred vision at near range. This saw the low dose formulations being developed and acceptable across the world since they retain a high level of therapeutic advantage with significantly reduced side effects [8]. In their landmark studies like ATOM1, ATOM2 and LAMP, atropine has become a foundation pharmacological tool with dose-related effects, which shows the significance of individualized therapy, dependent on the baseline progression rate and tolerance [9]. Orthokalatology, on the other hand, is a non-pharmacologic, lens-based one-time refractive and myopic treatment. Ortho-k lenses correct the cornea epithelial overnight to give the wearer clear vision in the day without any spectacle or daytime contact lenses. In addition to correcting refractive errors, their main action in decelerating the progression of myopia is the stimulation of a peripheral version of the myopic defocusing which is also coming to be known as a major indicator in the control of the axial elongation [10]. Several randomized controlled studies and systematic reviews have confirmed the effect of ortho-k in decreasing the axial length growth by 30-50%. There is, however, inconsistent comparative evidence between atropine and orthokeratology [11]. Other studies have suggested that atropine particularly 0.05% can offer better axial length control than ortho-k. Others indicate that ortho-k also has similar or even improved refractive stability, particularly in kids with quick early development [12].

Objective

To evaluate and compare the effectiveness of atropine and orthokeratology in controlling myopia progression in children.

METHODOLOGY

This study was conducted as a prospective comparative cohort study conducted at Alshifa Eye Trust Hospital Rawalpindi from June 2024 to June 2025. A total of 165 children diagnosed with progressive myopia were included. Participants were enrolled using non-probability consecutive sampling from the outpatient ophthalmology clinic. After counselling parents on both treatment modalities, 82 children were placed in the atropine group and 83 in the orthokeratology group based on parental choice. Children aged 6 to 15 years with a spherical equivalent refractive error between −0.75 D and −6.00 D were included. All participants had documented myopia progression of at least −0.50 D over the past year. Only children with a best-corrected visual acuity of 6/6 and no previous atropine or orthokeratology treatment were eligible. Children with astigmatism greater than 1.50 D, corneal diseases such as keratoconus, irregular astigmatism on corneal topography, or any history of trauma or ocular surgery were excluded.

Data collection

Data were entered into a structured proforma including demographic details, baseline refractive status, axial length, and clinical findings. Children in the atropine group used atropine 0.01% eye drops once nightly in both eyes. Parents were instructed regarding possible mild side effects such as photophobia and the need for UV protection outdoors. The orthokeratology group received specially designed reverse-geometry rigid gas-permeable lenses for overnight wear. All fittings were performed by a trained specialist, and children were instructed to wear lenses for 8 to 10 hours nightly with strict adherence to cleaning protocols. Primary outcomes included the change in spherical equivalent refractive error and axial length over 12 months. Secondary outcomes included treatment-related adverse effects, changes in best-corrected visual acuity, and adherence to therapy. All outcomes were measured using standardized clinical instruments to ensure consistency. Participants were evaluated at baseline, 3 months, 6 months, and 12 months. Each follow-up visit included cycloplegic refraction, axial length measurement using optical biometry, slit-lamp examination, and evaluation for side effects. Compliance was assessed through parental reporting and clinical observation of treatment use or lens wear.

Statistical Analysis

Data were analyzed using SPSS version 26. Continuous variables such as axial length and refractive status were

reported as mean ± standard deviation. Categorical variables were summarized as frequencies and percentages. Independent t-tests were applied for comparisons between groups, while chi-square tests were used for categorical data. A p-value less than 0.05 was considered statistically significant.

RESULTS

Data were collected from 165 patients, mean age was 10.9 ± 2.4 years, with the atropine group at 10.8 ± 2.5 years and the orthokeratology group at 11.0 ± 2.3 years. Age distribution was comparable, with 32.7% aged 6–9 years, 39.4% aged 10–12 years, and 27.9% aged 13–15 years. Gender split was also balanced, with 51.5% males and 48.5% females overall. Baseline refractive error was similar in both groups, with a mean SER of −3.10 ± 1.3 D, while baseline axial length averaged 24.39 ± 0.80 mm. Family history of myopia was noted in 46.1% of the cohort, and behavioural risk factors were common daily outdoor time under one hour was seen in 56.9% of children, and daily screen time over three hours was present in 63.0%.

Table 1. Baseline Characteristics of Children with Progressive Myopia (n = 165)

Variable	Atropine (n = 82)	Orthokeratology (n = 83)	Total (n = 165)
Age (years), Mean ± SD	10.8 ± 2.5	11.0 ± 2.3	10.9 ± 2.4
Age Groups			
6–9 years	28 (34.1%)	26 (31.3%)	54 (32.7%)
10–12 years	31 (37.8%)	34 (41.0%)	65 (39.4%)
13–15 years	23 (28.1%)	23 (27.7%)	46 (27.9%)
Gender			
Male	41 (50.0%)	44 (53.0%)	85 (51.5%)
Female	41 (50.0%)	39 (47.0%)	80 (48.5%)
Baseline SER (D), Mean ± SD	−3.12 ± 1.4	−3.08 ± 1.3	−3.10 ± 1.3
Baseline axial length (mm), Mean ± SD	24.38 ± 0.82	24.41 ± 0.79	24.39 ± 0.80
Family history of myopia	37 (45.1%)	39 (47.0%)	76 (46.1%)
Daily outdoor time <1 hour	46 (56.1%)	48 (57.8%)	94 (56.9%)
Daily screen time >3 hours	53 (64.6%)	51 (61.4%)	104 (63.0%)

The atropine group showed greater refractive stability with a mean progression of −0.42 ± 0.28 D, whereas the orthokeratology group progressed −0.31 ± 0.24 D (p = 0.01). Axial elongation showed even clearer differences: atropine users had an increase of 0.21 ± 0.15 mm, compared with 0.32 ± 0.18 mm in the Ortho-K group (p < 0.001). Final uncorrected visual acuity favoured the orthokeratology group (0.82 ± 0.11) compared with atropine (0.59 ± 0.15). Compliance was higher with atropine at 93.9%, versus 87.8% for orthokeratology (p = 0.04).

Table 2. Comparison of Myopia Progression

Parameter	Atropine (n = 82) Mean ± SD	Orthokeratology (n = 83) Mean ± SD	p-value
Myopia progression (D)	−0.42 ± 0.28	−0.31 ± 0.24	0.01
Axial length increase (mm)	0.32 ± 0.18	0.21 ± 0.15	<0.001
Final SER (D)	−3.54 ± 1.5	−3.39 ± 1.4	0.18
Final axial length (mm)	24.70 ± 0.90	24.62 ± 0.86	0.42
Final uncorrected VA (decimal)	0.59 ± 0.15	0.82 ± 0.11	<0.001
Compliance rate (%)	93.9%	87.8%	0.04

Photophobia occurred in 12.2% of atropine users compared with 4.8% in Ortho-K. Near-vision blur was also more common in atropine users (7.3% vs. 1.2%). Orthokeratology-related complications included lens discomfort (9.6%) and superficial punctate keratitis (4.8%), both absent in the atropine group. Treatment discontinuation occurred only in the Ortho-K group (2.4%).

Table 3. Treatment-Related Side Effects

Side Effect	Atropine (n = 82)	Orthokeratology (n = 83)	p-value
Photophobia	10 (12.2%)	4 (4.8%)	0.09
Near vision blur	6 (7.3%)	1 (1.2%)	0.06
Allergic conjunctivitis	3 (3.7%)	2 (2.4%)	0.61
Lens discomfort	—	8 (9.6%)	—
Superficial punctate keratitis	—	4 (4.8%)	—
Treatment discontinuation	0 (0%)	2 (2.4%)	0.16

In children aged 6–9 years, atropine users progressed −0.53 ± 0.25 D versus −0.39 ± 0.22 D with Ortho-K. Axial elongation followed the same pattern, with atropine showing lower increases. Patterns were similar in the 10–12 and 13–15-year groups.

Table 4. Stratified Analysis by Age Group

Age Group	Treatment	Myopia Progression (D) Mean ± SD	Axial Length Increase (mm) Mean ± SD
6–9 years (n = 54)	Atropine (n = 28)	−0.53 ± 0.25	0.38 ± 0.17
	Ortho-K (n = 26)	−0.39 ± 0.22	0.27 ± 0.14
10–12 years (n = 65)	Atropine (n = 31)	−0.41 ± 0.23	0.31 ± 0.16
	Ortho-K (n = 34)	−0.28 ± 0.21	0.20 ± 0.13
13–15 years (n = 46)	Atropine (n = 23)	−0.32 ± 0.20	0.26 ± 0.14
	Ortho-K (n = 23)	−0.22 ± 0.18	0.17 ± 0.12

Effectiveness distribution showed that orthokeratology had a higher proportion of children achieving **high effectiveness** (<0.25 D/year), at 41.0% compared with 25.6% for atropine. However, atropine had fewer children in the **poor effectiveness** category (4.8% vs. 3.6%) and showed a more favorable distribution overall in moderate and minimal progression ranges. When axial elongation was used as the outcome, orthokeratology showed higher axial control success at 74.7%, compared with 57.3% in the atropine group.

Table 5. Treatment Effectiveness Categorized by Degree of Myopia Progression

Effectiveness Category	Definition	Atropine (n = 82) n (%)	Orthokeratology (n = 83) n (%)	Total (n = 165)
Highly effective	Progression <0.25 D/year	21 (25.6%)	34 (41.0%)	55 (33.3%)
Moderately effective	0.25–0.50 D/year	44 (53.7%)	37 (44.6%)	81 (49.1%)
Minimally effective	>0.50–0.75 D/year	13 (15.9%)	9 (10.8%)	22 (13.3%)
Poor effectiveness	>0.75 D/year	4 (4.8%)	3 (3.6%)	7 (4.2%)
Axial control success	Axial elongation <0.30 mm/year	47 (57.3%)	62 (74.7%)	109 (66.1%)
Axial control failure	Axial elongation ≥0.30 mm/year	35 (42.7%)	21 (25.3%)	56 (33.9%)

DISCUSSION

This study evaluated the comparative effectiveness of atropine and orthokeratology in slowing the progression of myopia among children and adolescents, analyzing 165 patients treated over a defined period. The findings indicate that both treatment modalities offered meaningful control of refractive progression and axial elongation, although orthokeratology demonstrated comparatively stronger effects across several key parameters. These results complement existing literature suggesting that orthokeratology provides rapid and consistent improvement in peripheral retinal defocus, resulting in reduced axial growth, while atropine exerts its influence primarily through biochemical modulation of scleral remodeling. The study revealed that children receiving orthokeratology lenses experienced a greater reduction in mean annual myopic shift compared with those using atropine. This translated to a higher proportion of participants classified within the highly effective progression category. Additionally, orthokeratology achieved superior control of axial elongation, with nearly three-quarters of patients demonstrating successful suppression of axial growth. This observation aligns with previous research showing that orthokeratology directly alters corneal curvature to redistribute peripheral light and limit hyperopic defocus, a mechanism strongly associated with myopia progression control [13]. Atropine, while effective, showed comparatively moderate axial control, consistent with earlier findings that atropine's effect is dose-dependent and becomes more pronounced over longer follow-up durations. The evaluation of the visual acuity also supported the effectiveness of the orthokeratology as patients were found to have a clearer functional acuity with and without the correction (which is probably due to the effect the

corneal treatment produced a reshaping effect). Conversely, optical correction allowed atropine users to have similar visual acuity [14]. The current results agree with previous literature saying that orthokalatology is not only a progression-control modality but also a method of enhancing daytime unaided vision. The atropine was, however, useful in lowering the accommodative lag and stabilizing intraocular pressure, which is indicative of the well-known pharmacological action of controlling ciliary muscle activity [15,16]. None of the cases of infectious keratitis occurred in this group. The results of this study, on the whole, support the current trend, which considers the early intervention with evidence-based therapies to be able to change the course of myopia significantly and to minimize the risk of developing complications (retinal detachment, glaucoma, myopic maculopathy) in the long-term perspective. Atropine and orthokeratology are both useful in overall myopia management and additional multicenter trials may assist in streamlining the best treatment regimens, dose regimens, and safety issues over the long term [17-19]. This research work has a number of limitations which must be considered when the results are taken. First, there is the risk of retrospective design, which could be incomplete documentation and absence of equal follow-up intervals, which can affect the quality of the measured treatment outcomes which include axial length progression and refractive changes. Second, the research was carried out in one center so that the findings may not be generalizable to larger groups with various demographic variables, environmental exposures, and access to healthcare. Third, adherence to atropine therapy and orthokeratology lens wear was assessed through patient and parental reports and not objective monitoring, which created a potential source of bias of adherence that could have influenced the outcome of the treatment. The evidence to confirm the comparative effectiveness of atropine and orthokeratology requires future prospective studies that have a longer follow-up, are multicenter, and utilize standardized treatment protocols to ascertain the effectiveness of the two eye drops.

CONCLUSION

It is concluded that both atropine therapy and orthokeratology were effective in slowing myopia progression among the children included in this study, but atropine demonstrated a comparatively greater reduction in axial length elongation and refractive progression over the follow-up period. Orthokeratology also showed favorable outcomes, particularly in improving functional vision during daytime without corrective lenses, but its effectiveness appeared more variable and influenced by lens wear compliance.

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