CASE REPORT

Linking Corneal Remodelling to Axial Growth: Induced Peripheral Myopic Defocus and Slow Axial Elongation During 23 Months of Orthokeratology in a 10-Year-Old Girl

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ARTICLE INFO

ARTICLE TYPE
Case Report

ARTICLE HISTORY
Received: June 29, 2026
Accepted: July 30, 2026
Published: August 14, 2026

KEYWORDS
Axial length, eye; Child; Contact lenses; Corneal topography; Myopia; Orthokeratologic procedures

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DOI
https://doi.org/10.59345/sjped.v4i1.319

ABSTRACT

Background: Childhood myopia is the commonest chronic eye disorder of school age, and its harm is carried by axial elongation rather than by blur. Orthokeratology reshapes the cornea overnight into an oblate profile that corrects central vision while imposing myopic defocus on the peripheral retina, but the mechanism is rarely measured in the same child in whom the outcome is measured.

Objective: To describe the optical mechanism, corneal remodelling, safety, and axial elongation during 23 months of overnight orthokeratology in a 10-year-old girl with progressive myopia.

Case presentation: A paediatric case was followed clinically for 23 months. Serial corneal topography, zonal refractometry, visual acuity, ocular examinations, and optical biometry were assessed. Reshaping was complete by day 26: central axial power fell from 45.60 D to 43.24 D in the right eye and from 45.67 D to 42.78 D in the left, and corneal asphericity reversed from prolate (Q −0.10 and −0.22) to markedly oblate (Q +0.94 and +0.93). Relative peripheral refraction at the 5 mm chord shifted from −0.62 D to −2.12 D in the right eye and from −0.63 D to −2.13 D in the left, corresponding to induced relative peripheral myopic defocus of −1.50 D per eye. Axial length rose by 0.10 mm and 0.11 mm between months 16 and 23, approximately 0.17 and 0.18 mm per year. A transient punctate epitheliopathy at month 11 resolved without interrupting treatment.

Conclusion: Overnight orthokeratology produced durable corneal remodelling and peripheral myopic defocus, with slow axial elongation and a reversible minor epithelial event in this child. Baseline axial-length measurement remains essential for treatment monitoring.

1. Introduction

Myopia has moved from a refractive inconvenience to a public-health problem of the paediatric age group, and the scale of it is now documented in population studies large enough to leave little room for argument. A cross-sectional survey of 864,828 children aged 6 to 16 years drawn from 1,348 schools in Tianjin, China, with a participation rate of 95.05%, recorded an overall myopia prevalence of 54.71% (95% confidence interval 54.60% to 54.81%), higher in girls (57.58%) than in boys (52.05%), with moderate myopia in 19.09% and high myopia in 5.43% of children in the six central districts, and with the steepest single-year increase in prevalence occurring at age 8.[1] The Wuhu Children and Adolescents Eye Study, which screened 315,569 children aged 2 to 19 years from 513 schools with 95.6% participation, found myopia — defined there as a spherical equivalent of −1.00 D or worse — in 56.92% and high myopia in 4.31% overall, rising to 92.18% and 18.57% respectively among high-school students.[2] Closer to the Indonesian setting, a school-based study of 647 secondary students in Hue City, Vietnam, found a myopia prevalence of 48.7% using the more inclusive threshold of −0.50 D or worse, with a mean spherical equivalent of −0.92 ± 1.62 D and a mean axial length of 23.32 ± 1.07 mm, and reported that almost two-thirds of the myopic students were not wearing spectacles at all.[3] The three prevalence figures quoted here are therefore not directly comparable with one another, because the diagnostic thresholds differ. Vietnam is used as the regional comparator because no recent population-based Indonesian prevalence study with refractive or biometric endpoints of comparable scale is available, which is itself a gap worth filling. Paediatricians and paediatric ophthalmologists in this region are therefore increasingly asked not simply to correct a child's blur but to slow the underlying process.

That underlying process is axial elongation. In the Wuhu cohort, longer axial length was strongly associated with the presence of myopia (odds ratio 3.71) and with high myopia (odds ratio 5.89).[2] Axial length is the structural variable that matters, because it is the variable that carries lifetime risk of retinal detachment, myopic maculopathy, glaucoma and early cataract. Two developments make it usable at the level of the individual child. The first is normative data: pooled analysis of 559,799 axial length measurements from 147,404 children and adolescents produced global centile charts, showing for example that the 50th-centile axial length of a 7-year-old girl is 22.35 mm in European and Australian populations and 22.67 mm in East Asia, values that diverge further with age.[4] Percentile-based monitoring appears to track myopia progression better than raw elongation rate; in a Taiwanese normative study of 2,997 schoolchildren plus 35 orthokeratology-treated myopic children, the rate of change in axial length percentile correlated with myopia progression more closely (Spearman's rho 0.64) than the raw axial elongation rate (Spearman's rho 0.57).[5] The second is age- and ethnicity-specific untreated growth rates. A pooled analysis of 14,593 observations from 6,208 children aged 6 to 16 years across 15 longitudinal studies in the United Kingdom, Sweden, Australia, China and Vietnam reported untreated axial elongation in myopic children of 0.58 mm per year at age 6 and 0.35 mm per year at age 10 in East Asian participants, against 0.43 and 0.26 mm per year at the same ages in European participants.[6] Those figures are the counterfactual against which any individual treated child should be judged.

Against this background, several optical and pharmacological interventions have been shown to slow axial elongation. A living Cochrane systematic review and network meta-analysis of 104 randomised trials in 17,509 children aged 4 to 18 years confirmed that untreated myopic children

progress by a median of −0.65 D in the first year, and ranked orthokeratology among the effective optical strategies alongside repeated low-level red-light therapy, high-dose atropine, peripheral-plus spectacle designs and multifocal soft contact lenses.[7] Orthokeratology occupies a distinctive place in this list because it is the only widely used method that corrects the child's vision and delivers the therapeutic optical signal with the *same* device, and because it does so without any daytime appliance at all.

The mechanism attributed to orthokeratology is peripheral myopic defocus. Overnight wear of a reverse-geometry rigid gas-permeable lens redistributes corneal epithelium, flattening the centre and steepening the mid-periphery, so that the peripheral retinal image plane moves in front of the retina while the fovea remains in focus. The magnitude of this effect has been quantified. A systematic review and meta-analysis of nine studies in 259 participants with a mean baseline spherical equivalent of −2.44 ± 0.27 D calculated a pooled myopic defocus of −2.56 D (95% confidence interval −2.21 to −2.91) at 30 degrees of eccentricity, and showed the effect is larger after a year or more of wear (−2.69 D) than in the first three months (−2.39 D).[8] A prospective controlled study of 41 orthokeratology children and 20 single-vision controls mapped the shift by annulus and found progressive myopic change from −0.35 ± 0.35 D at 15–30 degrees to −1.68 ± 1.41 D at 45–53 degrees, with no change in the controls.[9] Work in anisomyopic children has gone further, linking the size of the peripheral refractive shift at the nasal 20-degree location to the amount of axial elongation actually observed.[10]

Corneal shape is the substrate through which that optical change is produced, and it too can be measured directly. Fourier analysis of corneal power distribution in 116 eyes of children aged 8 to 13 years showed that the mid-peripheral power components generated by the lens predicted one-year axial elongation, and that lens geometries producing a stronger mid-peripheral profile achieved elongation of 0.10 ± 0.19 mm compared with 0.26 ± 0.21 mm for a fully spherical design.[11] A single-blind randomised clinical trial in 30 children with a mean age of 10.8 ± 1.8 years reported twelve-month axial elongation of 0.04 ± 0.18 mm with an aspherical lens against 0.25 ± 0.23 mm with a conventional three-zone spherical lens, together with greater measured corneal reshaping and less hyperopic defocus between 30 and 53 degrees of eccentricity.[12] The diameter of the flattened zone behaves in the same direction. In the Variation of Orthokeratology Lens Treatment Zone randomised trial, 45 Chinese children aged 6 to under 11 years were allocated to a 5 mm or a 6 mm back optic zone; after 24 months the 5 mm group had a smaller treatment zone (horizontal diameter 2.69 ± 0.28 mm against 3.84 ± 0.39 mm) and less axial elongation (0.15 ± 0.21 mm against 0.35 ± 0.23 mm, p = 0.005).[13] A second randomised trial in 131 children aged 8 to 12 years found axial elongation of 0.07 ± 0.11 mm with a modified small treatment zone against 0.14 ± 0.12 mm with a conventional zone at 12 months, and 0.17 ± 0.15 mm against 0.26 ± 0.16 mm at 18 months.[14]

Safety in children is the other half of the equation, and it has been characterised in large datasets. Pooled safety data from three prospective two-year trials comparing 125 orthokeratology wearers with 118 spectacle-wearing controls recorded 28 adverse events in 19 orthokeratology participants against a single event in the control group, with an incidence of 13.1 adverse events per 100 patient-years and roughly 40% of those events consisting of corneal abrasion or staining.[15] A multicentre retrospective study of 2,768 orthokeratology patients across five Chinese sites, accumulating 3,269 patient-years of wear, recorded no serious ocular adverse events; 300 adverse events occurred in 241 patients (8.7%), of which 175 in 134 patients (4.8%) were device-related, giving a device-related event rate of 5.4 per 100 patient-years (95% confidence interval 4.6 to 6.2), the commonest being corneal epithelial defects (n = 108).[16] A twenty-year single-centre series of 600 orthokeratology patients (1,193 eyes, mean age 13.2 years, mean follow-up 4.2 years) recorded no microbial keratitis at all, although infiltrative keratitis occurred in 20.2% of patients, predominantly within the first two years.[17] A multicentre Japanese study of 1,438 patients accumulating 7,415 person-years placed the incidence of microbial keratitis at 5.4 per 10,000 patient-years (95% confidence interval 1.0 to 9.8).[18] Where sight-threatening infection does occur, it is overwhelmingly behavioural: a case-control study of 20 *Acanthamoeba* keratitis cases against 59 matched orthokeratology controls found odds ratios of 26.46 for inadequate hand hygiene, 17.40 for topping off disinfecting solution, 13.04 for delayed lens-case replacement and 9.09 for rinsing with tap water.[19]

What is comparatively rare in the published literature is a single paediatric patient in whom the optical mechanism, the corneal substrate and the biometric outcome are all measured and reported together over a period long enough to be meaningful. Group studies report mean peripheral defocus in one paper and mean axial elongation in another; individual case reports usually document acuity and topography alone. The novelty of the present report lies in assembling the whole causal chain in one child: serial axial curvature and refractive power maps from the same instrument, zonal refraction measured over the central, 3 mm and 5 mm chords at baseline and at 23 months, corneal asphericity tracked across four time points, and optical biometry bracketing the final seven months of treatment; and in showing that the induced relative peripheral myopic defocus was identical in the two eyes to the last quarter-dioptre. The aim of this case report is therefore to describe the 23-month clinical course of overnight orthokeratology in a 10-year-old girl with progressive myopia, to quantify the optical and structural changes that accompanied it, to place the resulting axial elongation rate against contemporary published benchmarks, to document a transient corneal epithelial adverse event and its conservative management, and to draw from the principal limitation of this case the practical recommendation that axial length be measured before the first orthokeratology lens is dispensed.

2. Case Presentation

The complete clinical course, the refractive profile measured across the pupil, the evolution of corneal shape and the resulting axial elongation rate are summarised in Figure 1, which serves as a graphical abstract for the narrative that follows. As shown in Figure 1A, the child was observed for 24.9 months in total, of which 23.4 months were spent in overnight lens wear.

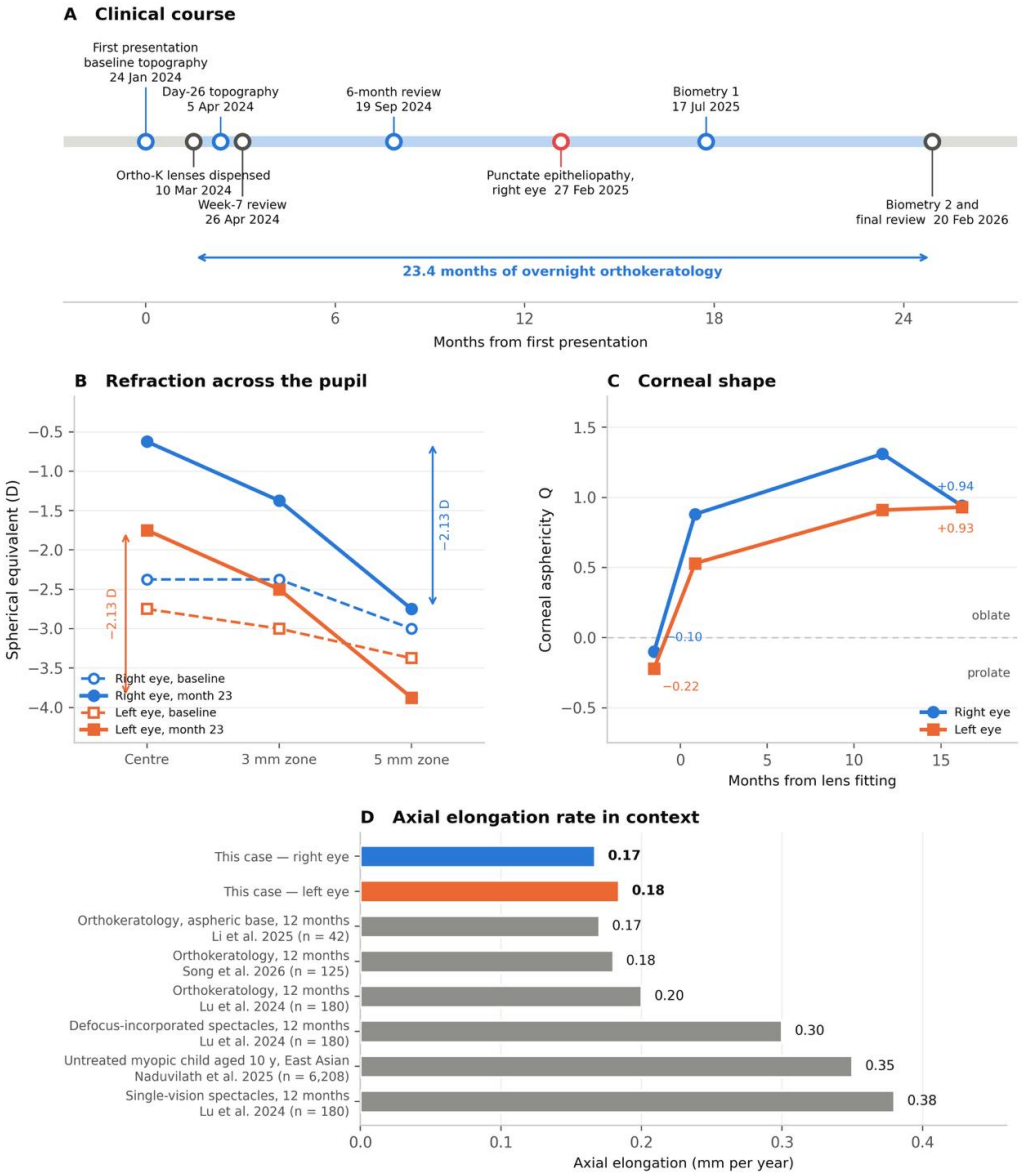

Figure 1. Clinical course and quantitative summary. (A) Timeline of the 24.9 months from first presentation to final review, of which 23.4 months were spent in overnight lens wear. (B) Spherical equivalent refraction measured over the central, 3 mm and 5 mm zones at baseline (open symbols, dashed) and at month 23 (filled symbols, solid); the vertical arrows mark the centre-to-5 mm gradient of −2.12 D in the right eye and −2.13 D in the left eye at month 23. (C) Corneal asphericity Q at four time points, showing inversion from prolate (negative) to oblate (positive) in both eyes. (D) Annualised axial elongation in this patient compared with published paediatric cohorts; grey bars are values reported by Lu et al. (2024), Song et al. (2026), Li et al. (2025) and Naduvilath et al. (2025), each cited in the text and reproduced with its sample size in the benchmark block of Table 4.

A 10-year-old girl (born August 2013) was brought by her mother to the eye clinic of Prof. dr. I.G.N.G. Ngoerah General Hospital, Denpasar, on 24 January 2024 with a one-year history of gradually worsening distance vision in both eyes. The mother had noticed increasingly frequent squinting. There was no redness, discharge, ocular pain or photophobia. The child had never worn spectacles. There was no history of allergy, systemic disease, ocular trauma, prematurity or previous ocular surgery, and no family history was recorded in the referring notes.

Uncorrected visual acuity was 0.125 in the right eye (oculus dexter, OD), improving to 0.4 with a pinhole, and 0.125 in the left eye (oculus sinister, OS), improving to 0.32 with a pinhole. Anterior and posterior segment examination was normal in both eyes. Clinic autorefraction recorded −1.50 −0.75 × 171° in the right eye and −2.50 −0.50 × 151° in the left. Corneal topography and total ocular wavefront refractometry were then performed on an OPD-Scan III refractive power/corneal analyser (Nidek Co. Ltd., Gamagori, Japan) as the basis for lens design. The two same-day scans recorded central refraction of −2.00 −0.25 × 160° and −2.25 −0.25 × 167° in the right eye and −3.00 DS and −2.75 DS in the left, values that are 1 to 2 dioptres more myopic than the clinic autorefractor reading in the right eye; this discrepancy is reported as found and is discussed below. The second of the two same-day scans is the examination the instrument itself carries in its paired comparison display, and it is therefore the one used for every derived quantity in this report; substituting the first scan changes the derived central spherical equivalent by 0.13 D or less and does not alter any conclusion. Baseline keratometry, corneal asphericity and zonal refraction are set out in Table 1, which also lists the anterior-segment and posterior-segment findings recorded at that visit. As detailed in Table 1, the baseline relative peripheral refraction over the 5 mm chord was −0.62 D in the right eye and −0.63 D in the left eye, and that value is the reference point for everything that follows.

Table 1. Baseline ophthalmic assessment at first presentation on 24 January 2024.

Parameter	Right eye	Left eye
Visual function		
Uncorrected visual acuity (decimal)	0.125	0.125
Visual acuity with pinhole	0.4	0.32
Refraction		
Clinic autorefraction	−1.50 −0.75 × 171°	−2.50 −0.50 × 151°
OPD-Scan central refraction, scan 1	−2.00 −0.25 × 160°	−3.00 DS
OPD-Scan central refraction, scan 2	−2.25 −0.25 × 167°	−2.75 DS
Central spherical equivalent (scan 2)	−2.38 D	−2.75 D
Corneal topography		
keratometry, steep meridian	46.23 D @ 81° (7.30 mm)	46.11 D @ 92° (7.32 mm)
keratometry, flat meridian	44.76 D @ 171° (7.54 mm)	44.76 D @ 2° (7.54 mm)
corneal astigmatism	1.47 D	1.35 D
Central axial power (apical radius)	45.60 D (7.40 mm)	45.67 D (7.39 mm)
Corneal asphericity, Q	−0.10	−0.22
Corneal eccentricity, e	0.31	0.47
Corneal spherical aberration @ 6.0 mm	0.287 µm	0.288 µm
Zonal refraction (spherical equivalent)		
Central zone	−2.38 D	−2.75 D
3 mm zone	−2.38 D	−3.00 D
5 mm zone	−3.00 D	−3.38 D
Relative peripheral refraction (5 mm – centre)	−0.62 D	−0.63 D
Ocular examination		
Anterior segment	Within normal limits	Within normal limits
Posterior segment	Within normal limits	Within normal limits
Photopic pupil diameter	5.16 mm	4.07 mm
Mesopic pupil diameter	7.40 mm	6.50 mm

Note: Values outside the age-expected range are shown in red. Refraction is reported as sphere, cylinder × axis. Topographic data were obtained using an OPD-Scan III refractive power/corneal analyser; two consecutive scans were acquired in each eye on the same day and both are repo rted.

Orthokeratology was selected after counselling the mother about the alternatives, the nightly wear routine, the hygiene requirements and the need for indefinite follow-up. The alternatives discussed were single-vision spectacles with observation, low-concentration atropine and myopia-control spectacle designs; the family preferred a strategy that combined myopia control with freedom from a daytime appliance, and the child, who was reluctant to wear spectacles at school, expressed the same preference. No refraction reported in this case, at baseline or subsequently, was performed under cycloplegia. Lens design was performed empirically with Easyfit software (Menicon Co. Ltd., Nagoya, Japan), which computes base curve, power and diameter from the measured corneal topography, the manifest refraction and the intended target correction. The child was fitted with Menicon Z Night reverse-geometry lenses, whose complete specification is set out in Table 2. The software returned a base curve radius of 8.10 mm for the right eye and 8.20 mm for the left, a lens power of 0.00 D, a total diameter of 10.60 mm, a tangent value of 55 and a sagittal height of 0.68 mm and 0.69 mm respectively; the full design specification is given in Table 2. As detailed in Table 2, the two lenses differed only in base curve and sagittal height, by 0.10 mm and 0.01 mm respectively, which is consistent with the small interocular difference in baseline corneal curvature documented in Table 1; all other parameters, including power, total diameter and tangent value, were identical.

Table 2. Orthokeratology lens design and fitting characteristics.

Parameter	Right eye	Left eye
Lens	Menicon Z Night	Menicon Z Night
Material	Rigid gas permeable, reverse geometry	Rigid gas permeable, reverse geometry
Fitting method	Empirical, Easyfit software	Empirical, Easyfit software
Base curve radius	8.10 mm	8.20 mm
Lens power	0.00 D	0.00 D
Total diameter	10.60 mm	10.60 mm
Tangent	55	55
Sagittal height	0.68 mm	0.69 mm

Parameter	Right eye	Left eye
Back optic zone diameter	Not recorded in the fitting file	Not recorded in the fitting file
Target correction	Full correction	Full correction
Wear schedule	Overnight, every night	Overnight, every night
Date dispensed	10 March 2024	10 March 2024
Movement on blinking at dispensing	Within physiological limits	Within physiological limits
Bubble formation / excess edge lift	None	None
Centration and stability at dispensing	Good	Good

Note: Lens parameters were generated empirically from baseline corneal topography, manifest refraction, and target correction using Easyfit software (Menicon Co. Ltd., Nagoya, Japan), and were not altered during the 23-month treatment period.

All topographic and refractive examinations reported here were performed during mid-morning or early-afternoon clinic sessions, with instrument timestamps between 10:09 and 12:16. The clinical record does not state the interval between lens removal on waking and each measurement, which is relevant because corneal shape after orthokeratology regresses gradually through the waking day.

Lenses were dispensed on 10 March 2024. At dispensing, lens movement on blinking was within physiological limits, there was no bubble formation and no excessive edge lift, and centration and stability over the corneal surface were judged good. The mother and child were taught insertion, removal, rubbing, rinsing and case care, were instructed never to rinse lenses or cases with tap water, and were warned to remove the lenses and attend immediately in the event of redness, pain, photophobia or blurred vision.

Serial axial curvature maps are shown in Figure 2, and the numerical values behind them are tabulated visit by visit in Table 3. At baseline (Figure 2A and Figure 2B) both corneas displayed the ordinary prolate bow-tie of a myopic child, with keratometry of 46.23 D at 81° and 44.76 D at 171° in the right eye and 46.11 D at 92° and 44.76 D at 2° in the left. Nine days after dispensing, the right cornea already showed central flattening, with keratometry falling to 45.61 D and 44.41 D and central refraction reducing to −1.25 −0.25 × 1°. By day 26 (Figure 2C and Figure 2D) the classic orthokeratology bull's-eye had formed in both eyes: a flattened central treatment zone encircled by a steepened mid-peripheral annulus. Corneal asphericity had reversed sign, from Q −0.10 to Q +0.88 in the right eye and from Q −0.22 to Q +0.53 in the left, and the instrument's own classification index labelled both corneas as showing a myopic refractive surgery pattern. Central refraction over the right cornea had overshot slightly into hyperopia at +1.25 −0.75 × 37°, an expected finding in the first weeks of overnight wear. The maps obtained at month 16 (Figure 2E and Figure 2F) show that the treatment zone was well centred in the left eye and mildly decentred infero-temporally in the right, while remaining stable in size and depth.

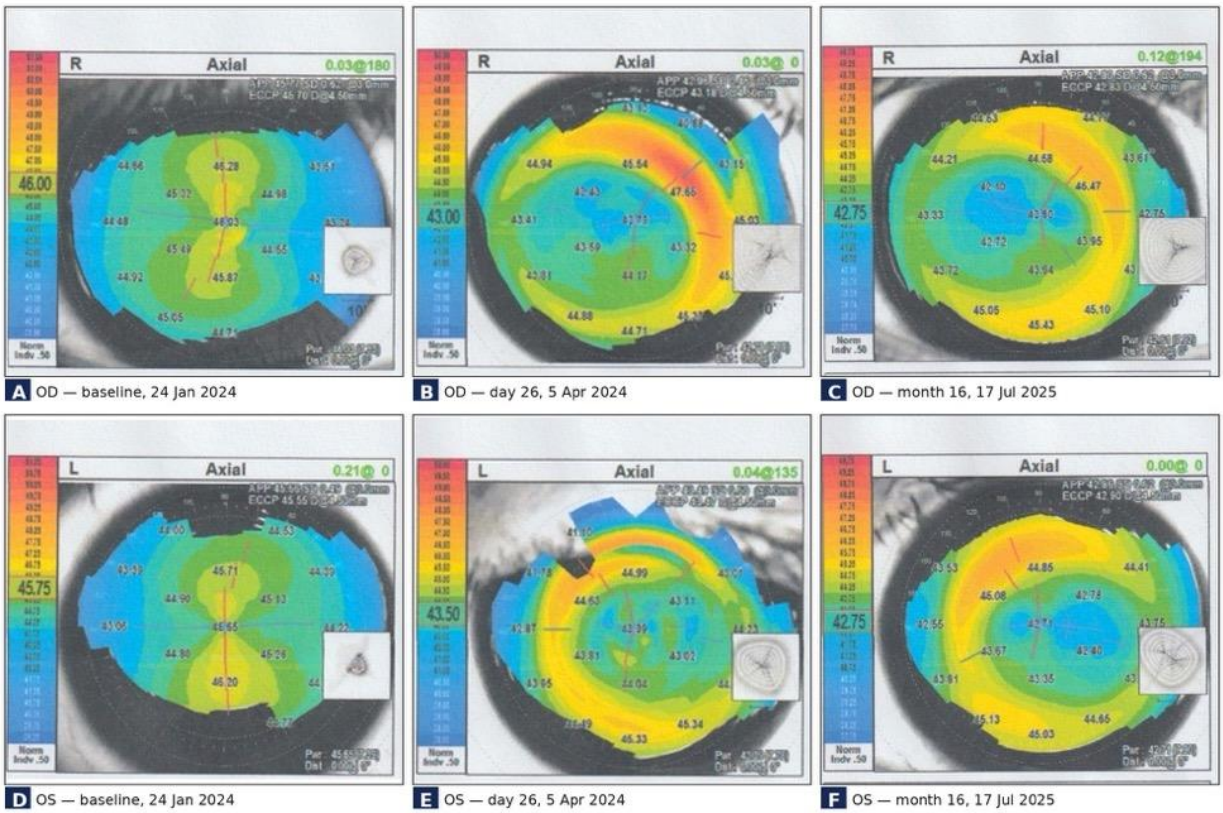

Figure 2. Serial axial curvature maps (OPD-Scan III). (A, B) Baseline, 24 January 2024: prolate bow-tie pattern in the right and left eye. (C, D) Day 26, 5 April 2024: the orthokeratology bull's-eye, with a flattened central treatment zone encircled by a steepened mid-peripheral annulus, is fully formed in both eyes. (E, F) Month 16, 17 July 2025: the treatment zone is stable, well centred in the left eye and mildly decentred infero-temporally in the right. Warm colours denote steeper and cool colours flatter curvature; the scale bar at the left of each panel is in dioptres.

The refractive consequence of that reshaping is displayed directly in Figure 3, which places the total ocular refractive power maps of each eye at baseline beside the corresponding map at month 16. At baseline (Figure 3A and Figure 3C) refractive power was almost uniform across the entrance pupil at approximately −2 to −3 D. As shown in Figure 3B and Figure 3D, at month 16 the centre of each map had moved close to plano, the values printed on the map itself reading +0.58, +0.08 and −0.26 D in the right eye, while the mid-periphery carried substantially more minus power, the printed local values reaching −3.52 D in the right eye and −6.46 D in the left. All the local values quoted in this paragraph are read directly from the annotated maps in Figure 3 and are not repeated in the tables. The full serial record of acuity, refraction, intraocular pressure, keratometry, asphericity and corneal status across all eight assessments is given in Table 3. As detailed in Table 3, corneal asphericity had already crossed from negative to positive in both eyes by day 26 and remained positive at every subsequent measurement.

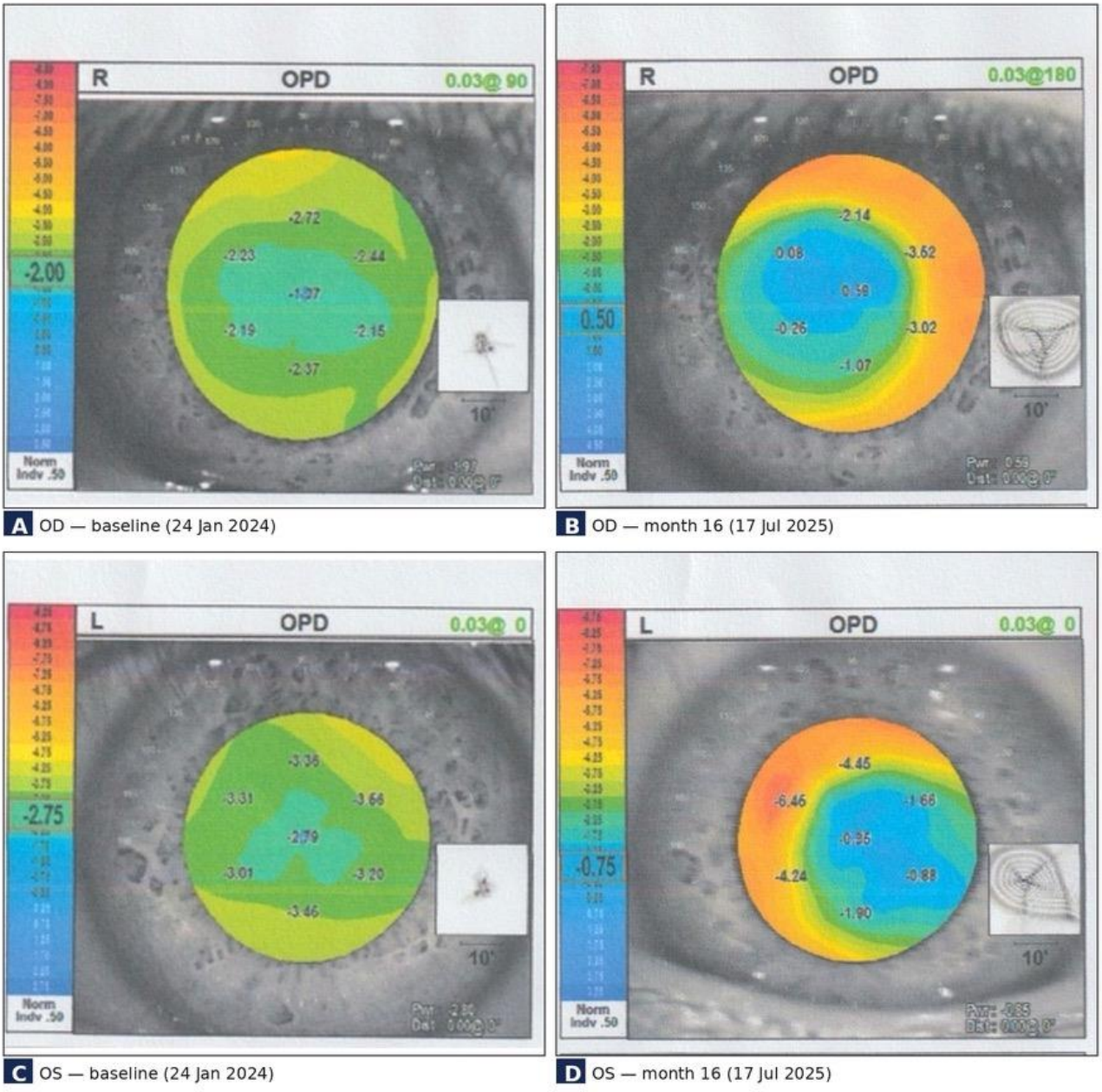

Figure 3. Total ocular refractive power maps before and during treatment. (A) Right eye at baseline and (B) at month 16. (C) Left eye at baseline and (D) at month 16. Refractive power is nearly uniform across the entrance pupil at baseline (approximately −2 to −3 D) and is redistri buted during treatment into a near-plano centre surrounded by a mid-peripheral annulus carrying substantially more minus power. Local values printed on the maps reach −3.52 D in the right eye and −6.46 D in the left.

Table 3. Serial clinical, refractive, and topographic findings throughout treatment.

Assessment	UCVA OD / OS	Refraction, right eye	Refraction, left eye	IOP OD / OS	K steep / flat OD; OS	Q OD / OS	Cornea
24 Jan 2024 Baseline, day −46	0.125 / 0.125	−1.50 −0.75 × 171°	−2.50 −0.50 × 151°	n.r.	46.23 / 44.76; 46.11 / 44.76	−0.10 / −0.22	Clear
10 Mar 2024 Lenses dispensed, day 0	n.r.	—	—	n.r.	n.r.	n.r.	Clear; good fit
19 Mar 2024 Day 9	n.r.	−1.25 −0.25 × 1°	n.r.	n.r.	45.61 / 44.41; n.r.	−0.10 / n.r.	Clear
5 Apr 2024 Day 26	n.r.	+1.25 −0.75 × 37°	−0.25 −0.75 × 108°	n.r.	44.88 / 42.78; 44.29 / 43.21	+0.88 / +0.53	Clear
26 Apr 2024 Day 47	0.63 / 0.80 (PH 0.8 / 1.0)	−0.50 −0.50 × 137°	−1.00 −0.75 × 161°	17 / 14	n.r.	n.r.	Clear; regular fluorescein pattern
19 Sep 2024 Day 193	1.00 / 0.80 (PH 1.0)	≤ −0.25 D residual	≤ −0.25 D residual	11 / 13	44.35 / 43.05; 43.95 / 42.78*	n.r.	Clear; no staining
27 Feb 2025 Day 354	n.r.	+0.25 −0.00	−0.50 −0.50 × 164°	17 / 19	44.47 / 42.40; 43.55 / 42.61	+1.31 / +0.91	PEE, inferior, right eye; fundus normal, CDR 0.3
17 Jul 2025 Day 494	0.60 / 0.80	−0.25 −0.25× 160° → 1.0	−0.25 DS → 1.0	15 / 16	44.18 / 42.78; 43.95 / 42.88	+0.94 / +0.93	Clear; staining negative
20 Feb 2026 Day 712	0.63 / 0.40 (PH 1.0 / 1.0)	−1.00 −0.75× 180° → 1.0	−0.75 −0.75× 160° → 1.0	n.r.	43.24; 42.78†	n.r.	Clear; staining negative

Note: Days are counted from lens dispensing on 10 March 2024. Abnormal or clinically significant entries are shown in red. UCVA, uncorrected visual acuity (decimal); PH, pinhole; IOP, intraocular pressure; K, keratometry; Q, corneal asphericity; PEE, punctate epithelial erosion; CDR, cup-to-disc ratio; n.r., not recorded.

At the review of 26 April 2024, 47 days after dispensing, the child reported comfortable, sharp and stable vision without spectacles and had no ocular symptoms. The lids and conjunctiva were normal and the corneas were clear with a regular fluorescein pattern. Intraocular pressure was 17 mmHg in the right eye and 14 mmHg in the left. Uncorrected acuity had improved to 0.63 (pinhole 0.8) in the right eye and 0.8 (pinhole 1.0) in the left, and autorefraction had fallen to −0.50 −0.50 × 137° and −1.00 −0.75 × 161° with a best corrected acuity of 0.8 to 1.0 in each eye. As detailed in Table 3, this represents a five-fold improvement in uncorrected acuity in the right eye within seven weeks of starting treatment, from 0.125 to 0.63.

By the review of 19 September 2024, approximately six months after dispensing, uncorrected acuity was 1.0 in the right eye and 0.8 improving to 1.0 in the left. The corneas were clear with no fluorescein staining and intraocular pressure was 11 mmHg in the right eye and 13 mmHg in the left. Keratometry recorded at that visit was 44.35 D and 43.05 D in the right eye and 43.95 D and 42.78 D in the left, and subjective refraction showed no more than −0.25 D of residual myopia with 6/6 acuity, indicating that refractive stabilisation had been achieved.

On 27 February 2025, 354 days after dispensing, the child remained comfortable and free of visual symptoms, but fluorescein staining was positive over the inferior cornea of the right eye, indicating superficial punctate epithelial erosion. As shown in Figure 4A, the cobalt-blue appearance of that eye at this visit carries an arrow marking the region identified at the slit lamp. There was no infiltrate, no anterior chamber reaction, no conjunctival injection and no discharge; the left cornea was clear. Dilated fundus examination, performed at baseline, at this visit and at the final review of 20 February 2026, showed sharp discs with a cup-to-disc ratio of 0.3 and normal retinae in both eyes on each occasion; undilated posterior segment assessment was performed at every other visit. Intraocular pressure was 17 mmHg in the right eye and 19 mmHg in the left. Autorefraction and subjective refraction showed minimal residual refractive error with binocular acuity of 1.0. The episode was managed conservatively: lens wear was continued, the insertion, removal and cleaning technique was reviewed in detail with mother and child, the lens case was replaced, and preservative-free ocular lubricant was advised on waking. The family was asked to return sooner if any symptom developed. The defect had resolved by the next review; because lens wear was never interrupted, what can be stated is resolution during continued wear with reinforced hygiene, and a contribution from spontaneous healing cannot be separated from the effect of the measures taken.

At the review of 17 July 2025, 494 days after dispensing, the child again reported comfortable spectacle-independent vision with no hyperaemia, discharge, pain or photophobia. Uncorrected acuity was 0.60 in the right eye, correcting to 1.0 with −0.25 −0.25 × 160°, and 0.80 in the left eye, correcting to 1.0 with −0.25 DS. Intraocular pressure was 15 mmHg and 16 mmHg. Anterior and posterior segment examination was normal and, as shown in Figure 4B and Figure 4C, fluorescein

staining was now negative in both eyes; the epithelial defect documented at month 11 had healed completely. As shown in Figure 4D and Figure 4E, the corresponding white-light appearance was of clear corneas and quiet conjunctivae. The corresponding entries in Table 3 record the same transition, from a fluorescein-positive right cornea at day 354 to negative staining in both eyes at day 494 and again at day 712.

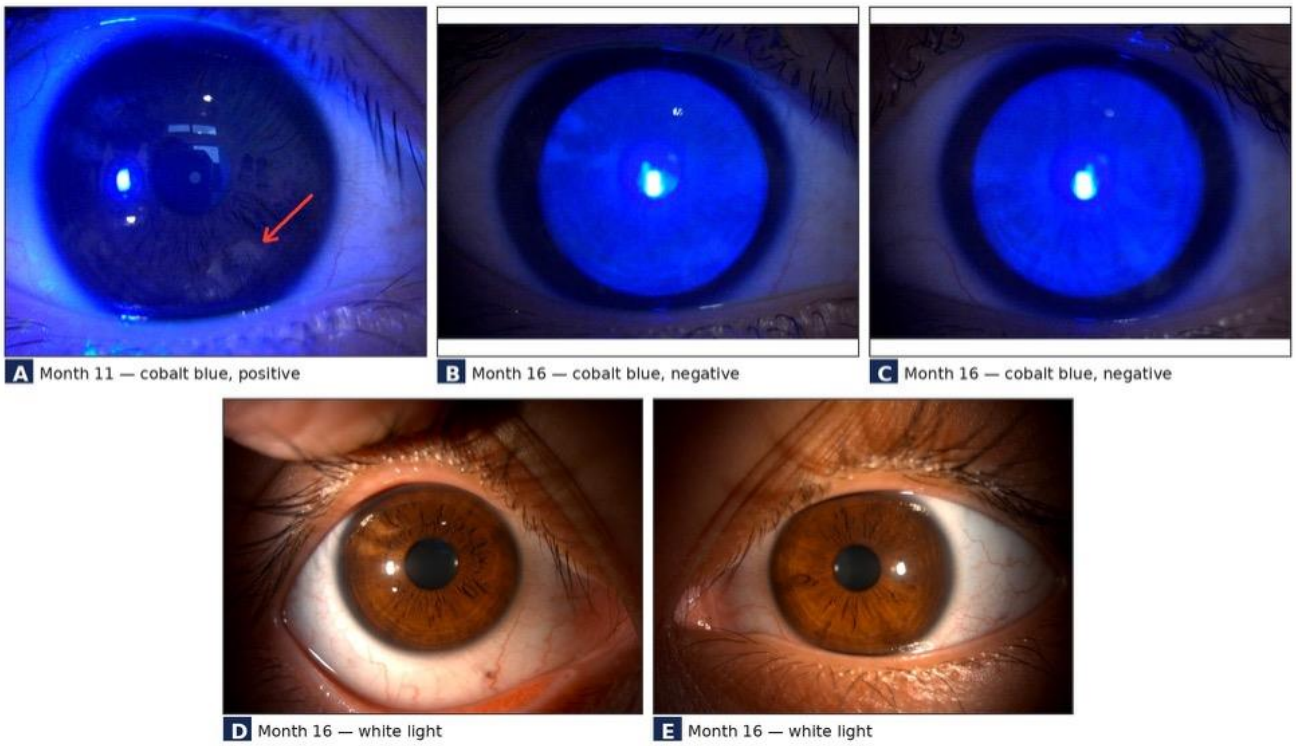

Figure 4. Anterior segment during treatment. (A) Right eye at month 11 (27 February 2025) under cobalt-blue illumination after fluorescein instillation; the arrow marks the inferior region of superficial punctate epithelial erosion identified at the slit lamp, which is faint on the archived clinical photograph. There was no infiltrate and no anterior chamber reaction. (B, C) Both eyes at month 16 (17 July 2025) under cobalt blue: fluorescein staining is negative and the epithelial defect has healed completely. (D, E) The same eyes under white light, showing clear corneas and quiet conjunctivae.

Optical biometry and posterior segment imaging were performed at the same visit. Axial length measured on an AL-Scan optical biometer (Nidek) was 23.85 mm in the right eye and 24.19 mm in the left, an interocular difference of 0.34 mm. Central corneal thickness was 495 µm and 499 µm, anterior chamber depth 3.83 mm and 3.82 mm, white-to-white diameter 12.3 mm and 12.4 mm, and mesopic pupil size 6.5 mm and 6.3 mm. Keratometry averaged over the 2.4 mm zone was 42.73 D and 42.60 D, and over the 3.3 mm zone 43.39 D and 43.06 D; all of these biometric values, together with their month-23 counterparts and the derived changes, are set out in Table 4. As shown in Figure 5A and Figure 5B, the optic discs, maculae and retinal vasculature were normal with no myopic degenerative change in either eye, and as shown in Figure 5C and Figure 5D, anterior-segment optical coherence tomography of each cornea demonstrated normal architecture with a smooth epithelial surface and no stromal opacity. All the biometric values quoted in this paragraph are reproduced, with their derived changes, in Table 4.

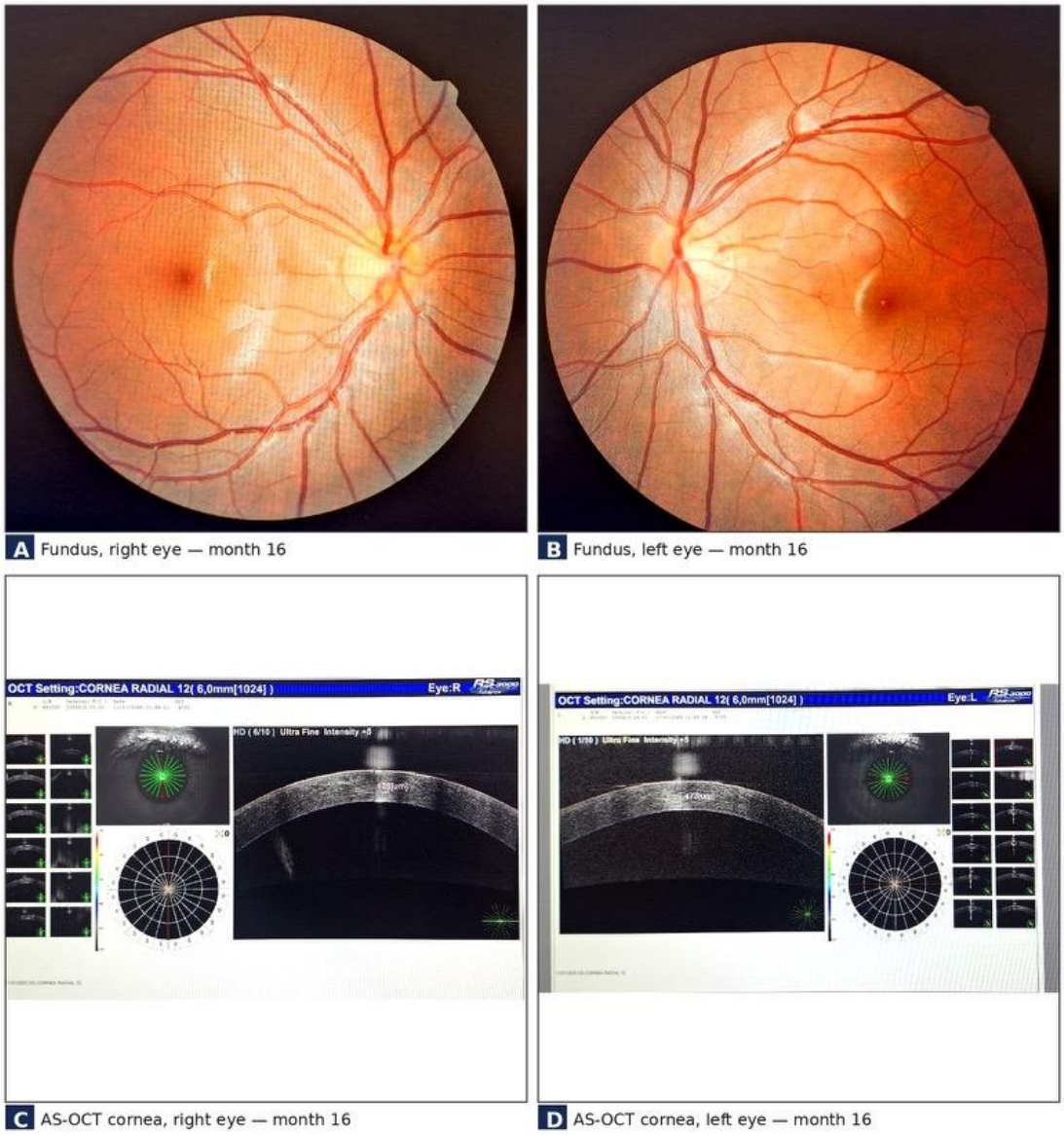

Figure 5. Posterior segment and anterior-segment optical coherence tomography at month 16. (A) Right and (B) left fundus, showing sharp optic disc margins, a cup-to-disc ratio of 0.3, normal maculae and normal retinal vasculature with no myopic degenerative change. (C) Right and (D) left anterior-segment optical coherence tomography of the cornea (radial 12-line, 6.0 mm scan), showing normal corneal architecture with a smooth epithelial surface and no stromal opacity. The on-screen caliper reads 473 µm at the marked point in each eye; this is not directly comparable with the central corneal thickness of 495 µm and 499 µm obtained by optical biometry at the same visit, because the two instruments apply different boundary-detection conventions and the caliper is placed at an operator-selected point rather than at the corneal apex.

The child was seen again on 20 February 2026, 712 days (23.4 months) after dispensing and 758 days after first presentation. She had no complaints. Anterior and posterior segment examination was normal, the corneas were clear and fluorescein staining was negative in both eyes. Uncorrected acuity was 0.63 improving to 1.0 with pinhole in the right eye and 0.4 improving to 1.0 with pinhole in the left, with binocular uncorrected acuity of 0.8. Subjective refraction of −1.00 −0.75 × 180° in the right eye and −0.75 −0.75 × 160° in the left restored 1.0 in each eye and 1.0 binocularly. Axial length had increased to 23.95 mm in the right eye and 24.30 mm in the left, and central corneal thickness to 506 µm and 504 µm, with anterior chamber depth of 3.97 mm and 3.98 mm.

Figure 6 presents the instrument's own paired comparison of the baseline and month-23 examinations for each eye and is the single most informative image in this report. In the right eye (Figure 6A) central axial power fell from 45.60 D at a radius of 7.40 mm to 43.24 D at a radius of 7.80 mm; in the left eye (Figure 6B) it fell from 45.67 D at 7.39 mm to 42.78 D at 7.89 mm. The zonal refraction panels within the same comparison are what allow the induced defocus to be calculated. In the right eye the spherical equivalent at the centre moved from −2.38 D to −0.63 D while the spherical equivalent over the 5 mm chord moved only from −3.00 D to −2.75 D; in the left eye the centre moved from −2.75 D to −1.75 D while the 5 mm chord moved from −3.38 D to −3.88 D. All derived quantities, together with the arithmetic used to obtain them and the external benchmarks against which they are compared, are presented in Table 4. As detailed in the derivation column of Table 4, every one of those quantities can be reproduced by hand from the source measurements listed in Table 1 and Table 3.

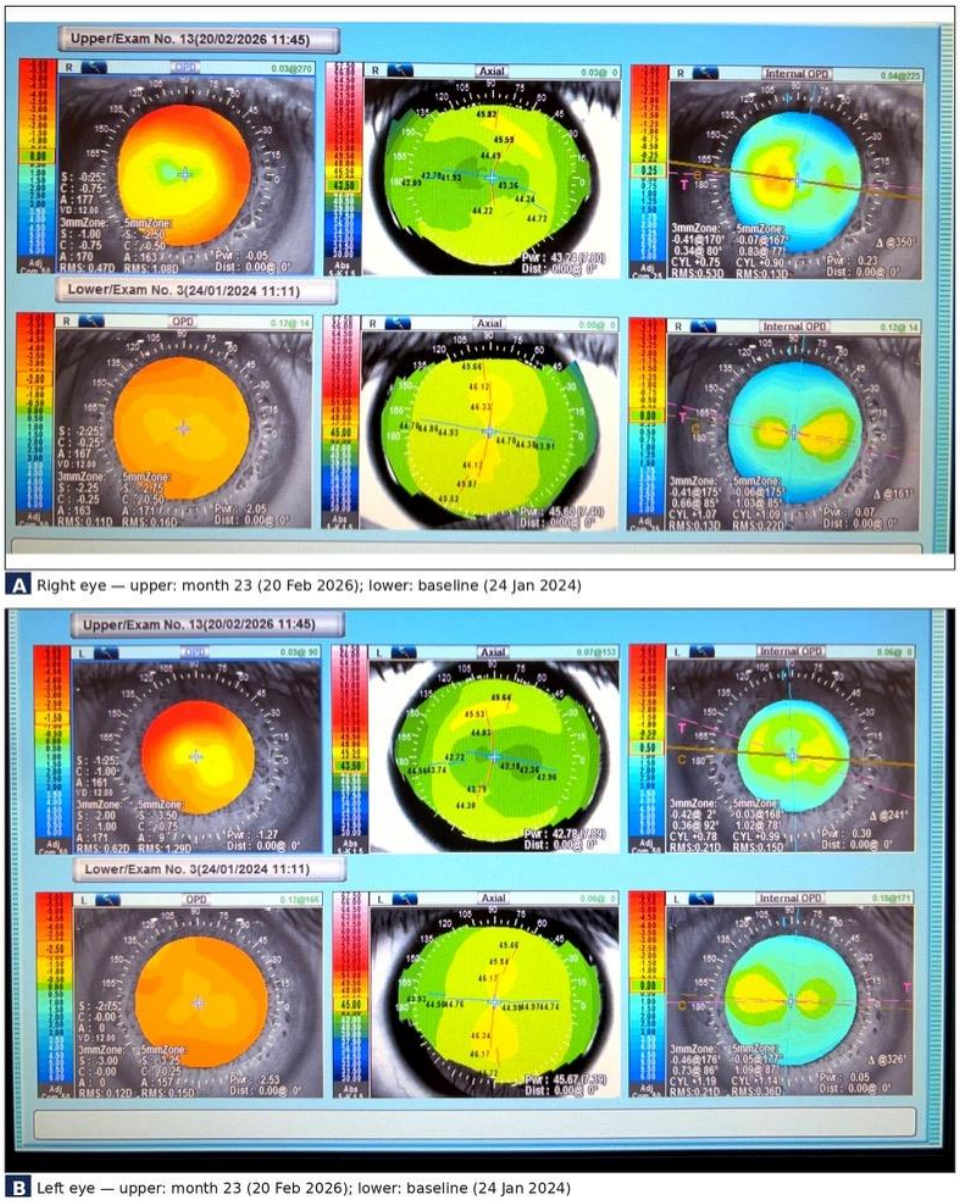

Figure 6. Paired instrument comparison of baseline and month-23 examinations. (A) Right eye and (B) left eye; in each panel the upper row is examination 13 of 20 February 2026 and the lower row is examination 3 of 24 January 2024. From left to right within each row: total ocular refractive power map, axial curvature map and internal (lenticular) power map. Central axial power fell from 45.60 D (radius 7.40 mm) to 43.24 D (radius 7.80 mm) in the right eye and from 45.67 D (radius 7.39 mm) to 42.78 D (radius 7.89 mm) in the left. The zonal refraction values printed within each panel are the source data for the induced relative peripheral myopic defocus reported in Table 4. Patient identifiers have been removed from all instrument displays.

Table 4. Derived quantities and external benchmarks for annualised axial elongation.

Quantity	Right eye	Left eye	Derivation
Corneal remodelling, baseline → month 23			
Central axial power change	−2.36 D	−2.89 D	43.24 − 45.60; 42.78 − 45.67
Central corneal radius change	+0.40 mm	+0.50 mm	7.80 − 7.40; 7.89 − 7.39
Corneal asphericity Q change (to month 16)	+1.04	+1.15	0.94 − (−0.10); 0.93 − (−0.22)
corneal astigmatism change (to month 16)	−0.07 D	−0.28 D	1.40 − 1.47; 1.07 − 1.35
Induced defocus, baseline → month 23			
RPR at the 5 mm chord, baseline	−0.62 D	−0.63 D	(−3.00) − (−2.38) = −0.62; (−3.38) − (−2.75) = −0.63
RPR at the 5 mm chord, month 23	−2.12 D	−2.13 D	(−2.75) − (−0.63) = −2.12; (−3.88) − (−1.75) = −2.13
Induced relative peripheral myopic defocus, 5 mm	−1.50 D	−1.50 D	(−2.12) − (−0.62); (−2.13) − (−0.63)
RPR at the 3 mm chord, baseline	0.00 D	−0.25 D	(−2.38) − (−2.38); (−3.00) − (−2.75)
RPR at the 3 mm chord, month 23	−0.75 D	−0.75 D	(−1.38) − (−0.63); (−2.50) − (−1.75)
Induced relative peripheral myopic defocus, 3 mm	−0.75 D	−0.50 D	(−0.75) − 0.00; (−0.75) − (−0.25)

Quantity	Right eye	Left eye	Derivation
Observation intervals			
Total observation, first presentation to final review	758 days (24.9 months)	—	24 Jan 2024 → 20 Feb 2026
Overnight lens wear	712 days (23.4 months)	—	10 Mar 2024 → 20 Feb 2026
Presentation to lens dispensing	46 days	—	758 − 712
Biometry interval, month 16 → month 23	218 days	—	17 Jul 2025 → 20 Feb 2026
Ocular growth, month 16 → month 23 (218 days)			
Axial length change	+0.10 mm	+0.11 mm	23.95 − 23.85; 24.30 − 24.19
Annualised axial elongation	0.167 mm/yr	0.184 mm/yr	0.10 × 365 ÷ 218; 0.11 × 365 ÷ 218
Interocular axial length difference	0.34 mm → 0.35 mm	—	24.19 − 23.85; 24.30 − 23.95
Central corneal thickness change	+11 µm	+5 µm	506 − 495; 504 − 499
Anterior chamber depth change	+0.14 mm	+0.16 mm	3.97 − 3.83; 3.98 − 3.82
Keratometry, 2.4 mm zone (month 16 → month 23)	42.73 → 43.46 D	42.60 → 43.15 D	AL-Scan average keratometry
Keratometry, 3.3 mm zone (month 16 → month 23)	43.39 → 43.85 D	43.06 → 43.54 D	AL-Scan average keratometry
White-to-white diameter (month 16 → month 23)	12.3 → 12.2 mm	12.4 → 12.2 mm	AL-Scan measurement
Mesopic pupil diameter (month 16 → month 23)	6.5 → 6.7 mm	6.3 → 6.3 mm	AL-Scan measurement
External benchmarks — annualised axial elongation	Reported value	n	Source
Orthokeratology, aspheric base, 12 months	0.17 mm/yr	42	Li et al.[20]
Orthokeratology, 12 months	0.18 mm/yr	125	Song et al.[21]
Orthokeratology, 12 months	0.18 mm/yr	31	Li et al.[22]
Orthokeratology, 12 months	0.20 mm/yr	180	Lu et al.[23]
Defocus-incorporated multiple-segment spectacles, 12 months	0.30 mm/yr	180	Lu et al.[23]
Untreated myopic child aged 10 years, East Asian	0.35 mm/yr	6,208	Naduvilath et al., pooled analysis of 15 longitudinal studies[6]
Single-vision spectacles, 12 months	0.38 mm/yr	180	Lu et al.[23]
This case, months 16–23	0.167 mm/yr	0.184 mm/yr	Right eye; left eye

Note: Derived values can be reproduced from the source measurements in Tables 1 and 3 using the derivation column. Spherical-equivalent values are rounded to two decimal places for display.

The clinical record does not document nightly wear time, nor whether any nights were missed around the epithelial event, so compliance cannot be reported as a measured variable. What can be reported is that the family attended all eight scheduled reviews across 24.9 months, that unaided acuity was maintained at every visit, and that the topographic treatment zone remained stable in size and depth throughout; adherence is inferred from these observations and is not a recorded measurement.

Three internal inconsistencies in the source clinical record deserve explicit statement rather than silent correction. First, the visit of 26 April 2024 was recorded in the notes as the five-week review, whereas the interval from dispensing on 10 March 2024 is 47 days, or just under seven weeks; the instrument-stamped dates have been used throughout this report. Second, the topographic examination described in the notes as having been performed on the day after dispensing carries an instrument date of 19 March 2024, nine days after dispensing, and the map described as the five-week map carries an instrument date of 5 April 2024, 26 days after dispensing. Third, the keratometry values recorded for the September 2024 visit appear only in the clinical narrative and could not be corroborated against an instrument printout; they are reported in Table 3 with that limitation marked. Total observation from first presentation to the final review was 758 days, of which 712 days were spent in overnight lens wear, which reconciles the alternative descriptions of this case as a 23-month and a 24-month follow-up.

3. Discussion

This case documents, in one child and with one instrument platform, each link in the chain by which orthokeratology is believed to work: a reshaped cornea, a redistributed refractive profile across the entrance pupil, and an axial elongation rate that falls within the range reported for treated children rather than untreated ones. The value of assembling these measurements in a single patient is that the treatment effect becomes auditable at the level of the individual, which is the level at which the clinician and the family actually make decisions.

The corneal substrate. The most reproducible finding in this case, plotted over time in Figure 1C and tabulated visit by visit in Table 3, is the reversal of corneal asphericity. The normal human cornea is prolate, flattening from centre to periphery, and this child's baseline values of Q −0.10 in the right eye and Q −0.22 in the left were unremarkable for her age. Within 26 days of overnight wear, Q had risen to +0.88 and +0.53, and by month 16 it stood at +0.94 and +0.93 — a change of +1.04 and +1.15 units respectively, and a complete inversion of the corneal profile from prolate to oblate. The magnitude of that change matters because the mid-

peripheral corneal power created by it is what generates the therapeutic optical signal. Fourier decomposition of corneal power distribution in 116 paediatric eyes showed that the components peaking mid-peripherally predicted subsequent axial elongation, and that lens designs producing a more pronounced mid-peripheral profile achieved one-year elongation of 0.10 ± 0.19 mm against 0.26 ± 0.21 mm for a fully spherical design.[11] The randomised comparison of an aspherical against a three-zone spherical lens in children of almost exactly this patient's age found the same direction of effect, with twelve-month elongation of 0.04 ± 0.18 mm against 0.25 ± 0.23 mm.[12] The oblate profile achieved here is therefore not a cosmetic curiosity of the topography display; it is the physical substrate of the treatment, and it is visible directly as the bull's-eye pattern shown in Figure 2C to Figure 2F and as the mid-peripheral minus annulus shown in Figure 3B and Figure 3D.

One feature of that trajectory deserves comment because it is visible in Figure 1C, is confirmed by the month-11 and month-16 rows of Table 3, and is not self-explanatory. Right-eye asphericity did not rise monotonically: it reached +1.31 at month 11 and then fell to +0.94 at month 16, whereas the left eye rose steadily to +0.93. Three explanations are available and the data cannot separate them. The value may have regressed genuinely, with a shallower treatment zone at the later visit; it may reflect the interval between lens removal and measurement, which the clinical record does not document and which materially affects corneal shape after orthokeratology; or it may be between-visit measurement variability. Uncorrected acuity, central axial power and induced peripheral defocus were all maintained at month 16 and again at month 23, so whatever the explanation, it had no functional consequence in this patient. Three measurements nevertheless point the same way and are worth setting beside one another, because separately they look like noise and together they look like a trend. First, right-eye asphericity fell from +1.31 at month 11 to +0.94 at month 16. Second, as detailed in the ocular-growth block of Table 4, average keratometry over the central 2.4 mm rose between months 16 and 23, from 42.73 D to 43.46 D in the right eye and from 42.60 D to 43.15 D in the left, with the same direction of change over the 3.3 mm zone. Third, central corneal thickness rose by 11 µm and 5 µm over that same final interval. A falling oblateness, a steepening central cornea and a thickening central cornea are together what a modest partial regression of the treatment effect would produce, and they occurred over the seven months in which the child was also growing. The alternative reading, that three independent measurement drifts happened to align, cannot be excluded from two biometric visits, and the functional measures did not deteriorate. What can be said is that the direction of all three is consistent, that it argues for measuring at shorter intervals in the next phase of follow-up, and that a lens review would be reasonable if the same direction persists.

The change in central corneal power is equally concrete. Comparing the instrument's own paired examinations, reproduced as Figure 6A and Figure 6B and quantified in the first block of Table 4, central axial power fell by 2.36 D in the right eye and 2.89 D in the left, with the apical radius lengthening by 0.40 mm and 0.50 mm. Those figures correspond closely to the baseline subjective myopia in each eye and confirm that the intended full correction was achieved and maintained for the whole of the observation period without any adjustment of the lens parameters listed in Table 2. As detailed in Table 2, no lens parameter was altered at any point in the 23 months, so the corneal changes reported here are attributable to a single unchanging device. Where full correction cannot be achieved, in higher myopia, partial-reduction designs supplemented by daytime spectacles are used instead, and have been shown to be both feasible and acceptable to children.[24] A randomised trial in 62 adolescents with −6.00 to −7.50 D of myopia found that orthokeratology combined with single-vision spectacles and peripheral-defocus rigid gas permeable lenses both outperformed spectacles alone on refractive and axial outcomes at 6, 12 and 18 months, with only five eyes developing grade 1 to 2 hyperaemia or epithelial staining.[25] Importantly for a paediatric readership, partial correction with residual daytime spectacle wear does not appear to cost the child the quality-of-life benefit: in 38 highly myopic Chinese children randomised to full or partial correction, the activities subscale of a paediatric refractive error profile improved with orthokeratology and did not differ between the two correction strategies across any of ten subscales.[26]

The optical mechanism, measured. The distinctive quantitative finding in this case is the induced relative peripheral myopic defocus. As shown in Figure 1B and derived line by line in Table 4, taking relative peripheral refraction as the spherical equivalent over the 5 mm chord minus the spherical equivalent at the centre, the right eye moved from −0.62 D at baseline to −2.12 D at month 23 and the left eye moved from −0.63 D to −2.13 D. The induced change was therefore −1.50 D in each eye, to the quarter-dioptre. The same calculation applied to the 3 mm chord gives a smaller induced defocus of −0.75 D in the right eye and −0.50 D in the left, which is what should be expected at a smaller eccentricity, and both eyes finished at an identical relative peripheral refraction of −0.75 D over that chord. That the two eyes, fitted with lenses differing in base curve, and starting from different degrees of myopia, converged on identical values is a strong internal consistency check on the measurement, and it supports the idea that the defocus produced is determined mainly by the lens geometry and the reshaping it imposes rather than by the starting refraction. Two qualifications belong here. The first is that the instrument reports sphere and cylinder in 0.25 D steps, so quantities computed from those values agree exactly more readily than quantities read from a continuous scale; the correct statement is that the two eyes agree to within the instrument's resolution, not that they are identical in an absolute sense. The second concerns the asymmetry at the 3 mm chord. The left eye began with −0.25 D of relative peripheral myopia over that chord while the right eye began with none, so the induced change differed (−0.50 D against −0.75 D) even though both eyes finished at the same value of −0.75 D. Read together, the two chords suggest that treatment moved both eyes towards a common peripheral refractive endpoint rather than adding a fixed increment to whatever each eye started with, an observation that would be worth testing prospectively in a series.

The magnitude sits sensibly within the published range. The meta-analysis of peripheral defocus in orthokeratology, pooling nine studies and 259 participants whose baseline spherical equivalent of −2.44 ± 0.27 D closely resembles this child's, reported −2.56 D of myopic defocus at 30 degrees of eccentricity.[8] Before that comparison is made, one difference must be stated plainly: the published series measure off-axis refraction at defined visual field eccentricities using open-field autorefraction with rotated fixation, whereas the values reported here are wavefront-derived averages over a defined chord, measured on axis. The two are related but are not the same quantity and should not be pooled or averaged across studies. With that caveat, an approximate angular equivalent is useful: for a cornea with an apical radius of about 7.8 mm, a semi-chord of 2.5 mm subtends roughly 19 degrees at the corneal centre of curvature. The corresponding visual field

angle depends on pupil position and nodal-point placement and is not identical; it is smaller than the angle subtended at the centre of curvature, so the comparison with the 30-degree literature values is conservative in the direction that understates rather than flatters the present measurement. Either way the 5 mm chord clearly samples an eccentricity well inside 30 degrees, so a smaller induced value at that location is exactly what should be expected. The regional analysis of relative peripheral refraction in 41 orthokeratology children reported −0.35 ± 0.35 D at 15 to 30 degrees, −0.96 ± 0.84 D at 30 to 45 degrees and −1.68 ± 1.41 D at 45 to 53 degrees, with the temporal and inferior quadrants shifting most and the nasal quadrant not shifting at all.[9] The −1.50 D measured here over the 5 mm chord is of the same order as the mid-eccentricity values in that series. The anisomyopia study is the one that connects this measurement to outcome: in 26 anisomyopic children followed for two years, the more myopic eye elongated by 0.26 ± 0.29 mm against 0.50 ± 0.27 mm in the fellow eye, and the amount of axial elongation was associated with the size of the peripheral refractive change at 20 degrees nasally.[10] Measuring the induced defocus in an individual child is therefore not merely descriptive. It is a candidate per-patient index of the optical dose being delivered, a hypothesis generated by a within-cohort association in anisomyopic eyes, which would need prospective validation before it could be used to titrate treatment.

The biometric outcome. Between 17 July 2025 and 20 February 2026, an interval of 218 days, axial length increased by 0.10 mm in the right eye and 0.11 mm in the left. Annualised, these correspond to approximately 0.17 mm and 0.18 mm per year; the exact quotients, 0.167 and 0.184 mm per year, are retained in Table 4 where the derivation is shown. That third decimal place should not be over-read. Each axial length is reported to two decimal places by an instrument whose repeatability is of the order of 0.02 mm, so the difference of two such measurements carries a propagated uncertainty of roughly 0.03 mm, which annualises to about 0.05 mm per year. The defensible statement is therefore an elongation rate of approximately 0.17 to 0.18 mm per year with an uncertainty of that order, and comparisons with published cohort means that differ from one another by less than 0.05 mm per year should not be treated as discriminating. Table 4 and Figure 1D place these values against contemporary cohorts. A one-year prospective comparative study of 375 children allocated in equal numbers to orthokeratology, myopia-control spectacles with highly aspherical lenslets and single-vision spectacles reported axial elongation of 0.18 ± 0.12 mm, 0.24 ± 0.14 mm and 0.36 ± 0.16 mm respectively.[21] A retrospective comparison of 166 children with low myopia reported twelve-month elongation of 0.17 ± 0.14 mm with an aspheric-base orthokeratology lens and 0.45 ± 0.16 mm with single-vision spectacles.[20] An ambispective cohort of 93 Chinese children reported 0.18 ± 0.08 mm with orthokeratology, 0.27 ± 0.08 mm with defocus spectacles and 0.36 ± 0.09 mm with single-vision spectacles.[22] The most informative comparator, however, is not another treated cohort but the untreated growth rate for a child of this age: the pooled analysis of 6,208 children placed untreated axial elongation in a 10-year-old myopic East Asian child at 0.35 mm per year and in a European child at 0.26 mm per year.[6] As Figure 1D and the benchmark block of Table 4 show side by side, this patient's measured rates of about 0.17 and 0.18 mm per year fall in the middle of the treated distribution and at roughly half the untreated and single-vision-spectacle rates. A three-year prospective cohort of 188 children provides a further useful frame: mean 36-month elongation was 0.58 mm overall, but high-compliance wearers elongated by 0.35 ± 0.07 mm against 0.72 ± 0.12 mm in low-compliance wearers, a difference that is larger than the difference between many lens designs.[27]

Two caveats attach to this comparison and both must be stated. First, axial length was not measured before treatment began, so the *change from baseline* cannot be computed and the rate reported here is a rate observed during the last seven months of a 23-month treatment course, not an average over the whole course. Second, a 218-day window is short, and biometric noise of the order of 0.02 mm between visits is not negligible relative to a 0.10 mm signal. The mitigation available in this case is that the measurement was made on the same optical biometer in the same clinic with consistent internal repeatability — six accepted readings per eye at month 16 with signal-to-noise ratios from 9.3 to 23.8, and readings clustering within 0.07 mm — and that both eyes moved in the same direction by almost the same amount. Where a pre-treatment axial length genuinely does not exist, a percentile-based approach offers a partial substitute: global centile charts allow an individual child's axial length to be positioned against a very large reference population,[4] and percentile change rate has been shown to track myopia progression more closely than raw elongation rate in a cohort that specifically included orthokeratology-treated children.[5] The clinical lesson for practices starting a myopia-control service is simply stated: measure axial length before the first lens is dispensed.

Predicting the long term from the short term. A ten-year longitudinal study of 101 children treated with orthokeratology has recently shown that the first year of treatment is unusually informative. First-year axial elongation exceeding 0.28 mm in children aged 8 to 9 years, or 0.29 mm in children aged 10 to 13 years, predicted an axial length above 26 mm at ten years and rapid late progression, with areas under the receiver operating characteristic curve between 0.952 and 0.995.[28] This patient's observed rate of 0.167 to 0.184 mm per year lies well below those thresholds. That is reassuring, but it is not a guarantee, both because her first treatment year was not measured and because a threshold derived in a Chinese cohort has not been validated in an Indonesian one.

Treatment zone position and size. The month-16 maps show mild infero-temporal decentration of the treatment zone in the right eye and good centration in the left. Clinicians instinctively treat decentration as a fitting failure, and it can certainly degrade optical quality, but the evidence on myopia control points the other way. A meta-analysis of nine retrospective studies in 1,503 Chinese children found that decentred treatment zones were associated with *less* axial elongation at both 12 months (standardised mean difference −0.45, 95% confidence interval −0.66 to −0.24) and 24 months (standardised mean difference −0.46, 95% confidence interval −0.68 to −0.24).[29] The most plausible explanation is that a decentred zone brings the steep annulus closer to the visual axis on one side, increasing the effective defocus over part of the retina. Decentration is also not primarily a fitting error: in 65 children fitted with spherical or toric designs, decentration did not differ by lens type, and its magnitude was predicted only by the corneal asymmetry vector, with an inferiorly oriented asymmetry exceeding 41.06 µm giving severe decentration in 35.29% of eyes at one month.[30] In this patient, the mild right-eye decentration visible in Figure 2E coexisted with entirely satisfactory uncorrected acuity, as detailed in Table 3, and with a slightly *lower* elongation rate than the well-centred left eye shown in Figure 2F, which is consistent with that literature. Back optic

zone diameter operates on the same axis of effect, and the evidence for it is now randomised rather than pooled: a 5 mm zone produced 0.15 ± 0.21 mm of axial elongation over 24 months against 0.35 ± 0.23 mm for a 6 mm zone,[13] and a modified small treatment zone produced 0.17 ± 0.15 mm against 0.26 ± 0.16 mm at 18 months.[14] The back optic zone diameter of the lens fitted to this child is not recorded in the fitting file, and Table 2 now says so; the design was a standard Menicon Z Night rather than a reduced-optic-zone variant. A smaller optic zone therefore remains a plausible but unverified escalation option should her elongation rate rise, and the zone diameter should be recorded routinely in any future case of this kind.

The corneal epithelial event. The transient inferior punctate epitheliopathy of the right eye at month 11 is the kind of event that determines whether a family continues treatment, and its management deserves comment. It was asymptomatic, unilateral, unaccompanied by infiltrate or anterior chamber activity, and had healed completely by the next review. Events of this type are common and expected. In the pooled analysis of three prospective trials, about 40% of adverse events in orthokeratology wearers were corneal abrasion or staining, and the overall incidence was 13.1 events per 100 patient-years against a single event across 118 spectacle-wearing controls.[15] In a three-year prospective cohort of 188 children, corneal staining occurred in 8.0%, lens intolerance in 5.3% and conjunctival redness in 10.6%, all resolving within 3.2 to 6.0 days.[27] The three-arm randomised trial comparing orthokeratology with 0.04% and 0.01% atropine recorded slight corneal fluorescein staining in 19 of 72 orthokeratology wearers, or 26.4%.[31] The largest recent safety dataset, covering 2,768 patients and 3,269 patient-years across five centres, reported adverse events in 8.7% of patients and device-related events in 4.8%, a rate of 5.4 device-related events per 100 patient-years, with corneal epithelial defects the commonest single category and no serious ocular adverse event at all.[16] An event of the kind this child experienced is therefore an expected part of treatment rather than a signal of failure, and quoting these incidence figures to families before the first lens is dispensed is the honest counterweight to the efficacy figures.

What separates a benign event from a sight-threatening one is behaviour rather than optics. The twenty-year series of 600 patients recorded no microbial keratitis but infiltrative keratitis in 20.2%, with risk raised by water sports, meibomian gland dysfunction and higher baseline spherical equivalent.[17] The multicentre incidence estimate of 5.4 microbial keratitis cases per 10,000 patient-years is reassuringly low.[18] The *Acanthamoeba* case-control study is the one that should shape the counselling script: the dominant risks were inadequate hand hygiene, topping off solution, delayed case replacement, tap-water rinsing and continuing to wear a lens that had become uncomfortable.[19] Every one of those is modifiable at the chair side, and each was revisited with this family at the month-11 visit. The decision to continue lens wear rather than suspend it was based on the absence of infiltrate, pain and anterior chamber reaction, the unilaterality of the finding, and the availability of prompt review; a different judgement would have been appropriate had any of those been absent.

Corneal thickness and structure. As detailed in the ocular-growth block of Table 4, central corneal thickness measured by optical biometry rose from 495 µm to 506 µm in the right eye and from 499 µm to 504 µm in the left between months 16 and 23, while anterior chamber depth rose by 0.14 mm and 0.16 mm. These changes are small and are within the range attributable to measurement variability and normal growth over seven months in a 12-year-old. They should not be read as evidence of stromal oedema, and no clinical sign of oedema was present. Anterior-segment optical coherence tomography, shown in Figure 5C and Figure 5D, demonstrated normal corneal architecture in both eyes. Where epithelial thickness has been mapped directly by anterior-segment optical coherence tomography in 63 orthokeratology eyes, the central 0 to 2 mm epithelium thinned by 7.54 ± 5.46 µm, paracentral thinning was greatest temporally, and the mid-peripheral and peripheral epithelium thickened, with the central change correlating with the target refractive power.[32] A randomised crossover trial manipulating reverse-curve height confirmed that the reverse zone thickens in proportion to the design, at the cost of higher higher-order aberration.[33] These redistributions are largely reversible, but not instantly. In 24 children followed for 37 months, one month without lenses left flat and steep keratometry still short of baseline even though intraocular pressure and anterior chamber depth had fully recovered.[34] In 110 long-term wearers stopped for about a month, corneal astigmatism changed by 0.24 ± 0.33 D after spherical and 0.32 ± 0.32 D after toric lenses — about a quarter of a dioptre on average — with larger changes in younger children and after longer wear.[35] Over a longer horizon the picture is reassuring: in 22 eyes with a mean 64.8 ± 22.6 months of previous wear, measured corneal parameters after discontinuation were comparable to matched controls by six months.[36] A planned treatment break in this child should therefore be scheduled with a recovery interval of weeks, not days.

Where this treatment sits among the alternatives. Orthokeratology is one option among several, and a paediatric readership is entitled to a fair comparison. Against myopia-control spectacles, the direct one-year comparison in 375 children favoured orthokeratology (0.18 versus 0.24 mm),[21] and a three-arm prospective study of 540 children aged 7 to 14 years, of whom 496 completed a year, found axial elongation of 0.20 ± 0.18 mm with orthokeratology, 0.30 ± 0.22 mm with defocus-incorporated multiple-segment spectacle lenses and 0.38 ± 0.19 mm with single-vision spectacles.[23] The direction is consistent but the absolute differences are small, and they are not uniform across ages: in a retrospective comparison of 1,683 children wearing highly aspherical lenslet spectacles and 1,192 wearing orthokeratology, the spectacle lens was better in 8-to-10-year-olds at one year (0.16 ± 0.19 mm against 0.22 ± 0.17 mm) and at two years (0.32 ± 0.27 mm against 0.37 ± 0.24 mm), with no difference in older children and an advantage for orthokeratology in moderate myopia.[37] Spectacle options are meanwhile improving and are supported by long follow-up: a five-year study of highly aspherical lenslet spectacles in 43 children reported 0.67 ± 0.06 mm of axial elongation against an estimated 1.40 mm for single-vision correction,[38] and a two-year multi-site United Kingdom trial of defocus-incorporated multiple-segment lenses in 108 children found 0.30 ± 0.03 mm of elongation at 24 months, with 91% of children growing more slowly than average untreated eyes.[39] Against soft dual-focus lenses, a retrospective comparison of 239 eyes found annualised elongation of 0.20 mm with dual-focus soft lenses and 0.24 mm with orthokeratology, with the soft lens superior only in children older than 10 years and the two comparable in younger children.[40] Combination therapy adds a further increment, and here the evidence is randomised on both sides. A two-year trial in 96 children reported 0.33 ± 0.17 mm of elongation with 0.01% atropine plus orthokeratology against 0.43 ± 0.16 mm with orthokeratology alone,[41] and the two-year AOK randomised trial in 96 Chinese children aged 6 to under 11 years reported 0.17 mm (standard error 0.03) against 0.34 mm (0.03),

together with greater choroidal thickening (+22.6 µm against −9.0 µm) and a higher incidence of photophobia in the combination arm.[42] A three-arm randomised trial found that 0.04% atropine slowed two-year axial growth by 0.08 mm (95% confidence interval 0.003 to 0.15) relative to orthokeratology alone.[31] Adding atropine would be a reasonable next step in this child if her elongation rate were to rise.

Two mechanistic observations round out the picture. Choroidal thickening is now a recognised early signal of effective myopia control. In a prospective comparison of 25 children on orthokeratology and 29 on single-vision spectacles, subfoveal choroidal thickness rose by 8.9 ± 17.4 µm at three months while axial elongation over the year was 0.17 ± 0.14 mm against 0.28 ± 0.16 mm in the controls, and mediation analysis attributed 44.8% of the treatment effect on axial elongation to the change in total choroidal area.[43] A prospective study incorporating a six-month pre-treatment run-in in 20 children showed that the choroid tended to thin before treatment and thickened once orthokeratology began, with retinal thickness peaking at +2.54 µm at six months.[44] Interestingly for this patient, choroidal thickening after one month of wear (17.74 ± 8.89 µm in low myopia and 18.25 ± 8.98 µm in moderate myopia) correlated with the magnitude of treatment zone decentration as well as with baseline spherical equivalent,[45] an observation consistent with, but not establishing, the proposition that a mildly decentred zone is not simply a defect; that study was not designed to test the proposition and the association may equally mark something else. Choroidal imaging was not performed in this patient and would be a valuable addition to future follow-up. Finally, the question of what happens on stopping is not fully settled. A randomised trial of 308 children in which 279 completed 12 months of orthokeratology or single-vision spectacles followed by a one-month withdrawal found axial elongation of 0.22 ± 0.11 mm against 0.35 ± 0.08 mm during treatment and no noticeable myopic rebound over the month off lenses,[46] whereas a 37-month observational series recorded a further 0.07 mm of axial elongation during a single lens-free month, with the per-month rate differing significantly from the rates at 12, 24 and 36 months.[34] The two disagree, and the closer analogue to this patient is the second: her 23 months of continuous wear resemble the 37-month series far more than the 12-month randomised comparison, so a treatment break should be planned on the assumption that some acceleration may occur rather than none. The follow-on cohort of a randomised soft multifocal trial found that switching 235 adolescents to single-vision lenses increased axial elongation by 0.03 mm per year (95% confidence interval 0.01 to 0.05) and myopia progression by −0.17 D per year (95% confidence interval −0.22 to −0.12).[47] Treatment should therefore be tapered rather than stopped abruptly, and not before axial growth has plateaued.

Quality of life and adherence. The functional argument for orthokeratology in a child of this age is not only biometric. In the ambispective comparison of 93 children, the orthokeratology group scored highest on overall vision, far vision, appearance, satisfaction, activities, peer perception and total score of a paediatric refractive error profile.[22] This patient maintained functional unaided vision for the entire treatment period, needing no daytime optical appliance, and attended every scheduled review. Given that compliance produced a two-fold difference in three-year axial elongation in a 188-child cohort,[27] that adherence is itself a therapeutic asset and should be recorded and praised as such at every visit.

Positioning the measurement against a population. Having argued that axial length is the endpoint that matters, it is reasonable to ask where this child sits on the population distribution. The published global centile charts give a 50th-centile axial length for girls of 22.35 mm at age 7 years in European and Australian populations and 22.67 mm in East Asia, rising by age 18 to 23.31 mm and 24.36 mm respectively.[4] At 12 years and 6 months this patient measured 23.95 mm and 24.30 mm, values that already exceed the European and Australian 18-year median and approach the East Asian one. No Indonesian population contributed to the pooled dataset and the charts are stratified by broad region rather than by country, so a precise centile cannot responsibly be assigned; what can be said is that her axial length is long for her age against either available reference, which is consistent with a myopia that was progressing before treatment started and which reinforces rather than undermines the case for continued treatment. Percentile tracking of the kind validated in Taiwanese schoolchildren would be the natural way to monitor her from here.[5]

Limitations. Five limitations bound the conclusions. Pre-treatment axial length was not measured, so no within-patient baseline elongation rate exists and the comparison to published cohorts is indirect. Biometry was performed at only two time points, so the reported rate rests on a single 218-day interval. Peripheral refraction was derived from zonal wavefront refractometry over corneal chords rather than from off-axis autorefraction at defined visual field angles, so the values are not directly interchangeable with those in the peripheral defocus literature, though they are internally consistent between eyes and across visits. No refraction in this case was performed under cycloplegia, which in a child of this age can overstate myopia and is a plausible partial explanation for the disagreement between the clinic autorefractor and the wavefront refractor at baseline. And a single case, however thoroughly instrumented, cannot establish efficacy; it can only demonstrate that the proposed mechanism and the expected outcome were both present and measurable in one child.

4. Conclusion

Overnight orthokeratology in this 10-year-old girl produced rapid and durable corneal remodelling and maintained functional unaided vision for 23 months without any daytime optical appliance. It was accompanied by an axial elongation rate of approximately 0.17 mm per year in the right eye and 0.18 mm per year in the left, with a propagated uncertainty of the order of 0.05 mm per year. Those values sit within the range reported for treated children and at roughly half the rate reported both for untreated myopic children of the same age and for single-vision spectacle wearers.

The measurements that make this case instructive are the intermediate ones. Corneal asphericity inverted from prolate to oblate, moving by more than a full unit of Q in each eye, and central axial power fell by 2.36 D and 2.89 D. Those corneal changes translated into a measured redistribution of refraction across the entrance pupil, with relative peripheral refraction at the 5 mm chord moving from −0.62 D to −2.12 D in the right eye and from −0.63 D to −2.13 D in the left eye: an induced relative peripheral myopic defocus of −1.50 D per eye, identical to within the instrument's 0.25 D resolution despite different lens base curves and different starting refractions. Documenting mechanism and outcome in the same patient converts a population-level rationale into an individual-level observation that a clinician can audit.

The single transient corneal epithelial erosion at month 11 illustrates the safety profile that should be described to

families before treatment begins: adverse events of this kind are common, usually minor and reversible, while the rare sight-threatening events are driven overwhelmingly by modifiable hygiene behaviour. Continuing treatment in the absence of infiltrate, pain or anterior chamber reaction, with reinforced technique and early review, was appropriate here and preserved 23 months of uninterrupted therapy.

Three practical points follow for paediatric practice. Axial length should be measured before the first orthokeratology lens is dispensed, because without it the most important outcome of treatment cannot be quantified. Zonal refraction across the pupil is available on instruments already present in many clinics and gives a direct, per-patient estimate of the optical dose being delivered. And mild treatment zone decentration, where uncorrected acuity is good and the cornea is quiet, is not by itself a reason to refit. Continued monitoring of this child, with the addition of choroidal imaging and axial length percentile tracking, and consideration of adjunctive low-concentration atropine should her elongation rate rise, is planned.

Declarations

Ethics approval and assent: This report describes routine clinical care delivered at the Ophthalmology Department, Faculty of Medicine, Udayana University / Prof. dr. I.G.N.G. Ngoerah General Hospital, Denpasar, Bali, Indonesia, and was conducted in accordance with the Declaration of Helsinki. Written parental consent for publication was obtained from the patient's mother, and age-appropriate assent was obtained from the child. All patient identifiers have been removed from every instrument display and clinical photograph reproduced in this article. The report was prepared in accordance with the CARE (CAse REport) guideline and the completed checklist accompanies this submission.

Data availability: All data generated or analysed during this case are included in this published article, principally in Table 1, Table 3 and Table 4 and in Figures 1 to 6. The underlying instrument printouts are held in the patient's clinical record and are available from the corresponding author on reasonable request, subject to the removal of identifying information.

Conflict of interest: The authors declare no conflict of interest.

Funding: This case report received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

Author contributions (CRediT): AE: Conceptualization, Investigation, Data curation, Visualization, Writing – original draft. ATH: Supervision, Methodology, Validation, Writing – review & editing. IGAMJ: Formal analysis, Validation, Writing – review & editing. SAW: Investigation, Resources, Writing – review & editing. All authors have read and approved the final version of the manuscript and agree to be accountable for all aspects of the work.

Acknowledgements: The authors thank the patient and her mother for permitting publication of this report, and the optometric and nursing staff of the Ophthalmology Department for their assistance with imaging and follow-up.

Use of artificial intelligence: No artificial intelligence (AI) tools were used in the preparation of this manuscript.

Note on the reference base: All 47 references were verified three times: the PubMed record was retrieved, the digital object identifier was matched against the Crossref REST application programming interface with title confirmation, and the publisher or PubMed web page was then retrieved directly for every reference. Every reference was published in 2023 or later and 44 of the 47 (93.6%) report original patient data; the three exceptions are evidence syntheses retained because each supports a claim that no single primary study supports.

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