DOI: 10.24292/01.OT.990625

Anisometropia and myopia progression – patient management guidelines

Joanna Przeździecka-Dołyk

Clinic of Ophthalmology, Medical University of Wroclaw
Head: associate prof. Anna Turno-Kręcicka, MD, PhD

HIGHLIGHTS

Vision in each eye in anisometropia and their cooperation may be disturbed by the occurrence of prismatic effects of lenses or changes in the cognitive system. Therefore, in addition to optical correction, constant monitoring of binocular vision parameters and proactive visual rehabilitation and education are also necessary.

ABSTRACT

Anisometropia, or a difference in refraction between the eyes, can lead to aniseikonia – a difference in the size or shape of retinal images. The main symptoms include asthenopia and disturbances in stereopsis and spatial perception, including disturbances in movement patterns. Incorrectly applied correction can result in fusion disorders, headaches, diplopia, or amblyopia. Treatment requires appropriately selected spectacle or contact correction, taking into account the degree of aniseikonia, binocular balance, and visual rehabilitation.
Pharmacological (e.g., atropine) and optical methods (DIMS glasses, MFSCL lenses, orthokeratology) are used to manage myopia progression. Their goal is to control myopic defocus at the periphery of the retina and slow down the growth of the eyeball, ideally with early implementation of therapy and lifestyle modifications (time outdoors, breaks from close-up work). Effective care requires cooperation between an ophthalmologist, optometrist, and in children, a pediatrician and educator to ensure proper visual development and functioning in the school environment.

Key words: anisometropia, aniseikonia, myopia, accommodation

A refractive error is an imperfection of the eye's optical system that results in blurred retinal image formation due to improper focusing of light onto the retina. The most common cause is a mismatch between the axial length of the eyeball and its refractive power, determined primarily by the curvature of the cornea and the crystalline lens. Consequently, patients experience reduced visual acuity and difficulty achieving clear vision at different viewing distances.
The most common refractive errors include:

1. Myopia (short-sightedness) – the image is focused in front of the retina, resulting in reduced distance vision.
2. Hyperopia (farsightedness; hypermetropia) – the image is focused behind the retina; in younger patients, clear vision may be maintained through accommodative effort.
3. Astigmatism – caused by irregular corneal curvature; light is focused at different meridians, leading to image distortion (the cornea lacks rotational symmetry).

Refractive errors may be corrected with spectacles, contact lenses, or refractive surgery (e.g., laser vision correction).
Myopia progression, defined as a gradual increase in the magnitude of myopia over time, is currently a major focus of eye care specialists. Clinically significant progression is commonly defined as an increase in refractive error of >0.50 D/year, expressed as spherical equivalent (SE). Myopia progression most often begins during school age and may continue until approximately 20–25 years of age, although progression into adulthood has also been reported in some individuals.
The principal and best-described mechanism underlying myopia progression is axial elongation of the eye (increased anterior–posterior length), which shifts the focal point anterior to the retina. Consequences include the need for more frequent spectacle or contact lens updates, an increased risk of high myopia, and a higher likelihood of sight-threatening complications (e.g., myopic retinal degeneration, retinal detachment, glaucoma).
Multiple risk factors have been identified, with the most important including genetic predisposition, high levels of near work (e.g., prolonged reading or screen use), and limited time spent outdoors in daylight. Therefore, careful monitoring of myopia progression is essential and should include:

- regular optometric and/or ophthalmologic examinations (typically every 6–12 months in children)
- assessment of refractive error and axial length measurements.

Anisometropia, defined as a condition in which the two eyes of the same individual have different refractive errors, may present a clinical challenge for eye care professionals. In practice, this means that one eye may be more myopic or hyperopic than the fellow eye, or may exhibit a different magnitude and/or axis of astigmatism. In rare cases, one eye may be hyperopic while the other is myopic.
Clinically, anisometropia is commonly considered when the interocular difference in refractive error exceeds:

- 1 D in hyperopia
- 3 D in myopia.

At the same time, these thresholds are not absolute. Clinicians should consider any interocular refractive difference that induces asthenopic symptoms as clinically relevant anisometropia and manage it accordingly. It should also be noted that one of the main challenges in anisometropia is the coexistence of aniseikonia, defined as a difference in retinal image size between the two eyes. Importantly, aniseikonia may involve differences not only in image size but also in image shape (e.g., meridional aniseikonia associated with significant interocular differences in astigmatism) [1, 2].
There are two main types of aniseikonia: static and dynamic (fig. 1). In static aniseikonia, the object perceived by each eye differs in size both during steady fixation and while the object is moving; importantly, the magnitude of the perceived size difference remains constant during movement.
In dynamic aniseikonia, the perceived image size changes during eye movements. This phenomenon is related to differences in prismatic effects and parallax when viewing through corrective lenses, particularly spectacles. As a result, the speed and trajectory of the perceived movement of the object may differ between the eyes, which can be explained by spectacle-induced prismatic effects described by Prentice's rule.

FIGURE 1

Two basic types of aniseikonia: static and dynamic.

Why is aniseikonia so important?

1. A large interocular image-size difference may impair binocular fusion, as the brain receives two retinal images that differ in size and/or focus.
2. It may cause significant visual discomfort, including dizziness, nausea (motion sickness), and headaches, and in children it may contribute to reduced visual development, including unilateral amblyopia.
3. If unrecognized and inadequately managed during visual development, aniseikonia may lead to abnormal or incomplete maturation of binocular vision, including impaired stereopsis.

TABLE 1

Methods for assessing the magnitude of aniseikonia.

Magnitude of aniseikonia*	Binocular summation (electrophysiology)	Binocular summation (contrast sensitivity)	Stereopsis	Subjective symptoms
0–0.75%	Binocular response amplitude greater than monocular (summation)	Normal binocular summation of contrast sensitivity	Good distance (10′) and near stereopsis (50″)	Clinically asymptomatic
1–2%	Binocular response amplitude greater than monocular (summation)	Normal binocular summation of contrast sensitivity	Satisfactory stereopsis for distance; good near stereopsis (50″)	Clinically asymptomatic
3%	Binocular response amplitude greater than monocular (summation)	Reduced binocular summation of contrast sensitivity	Reduced distance and near stereopsis	Asthenopia, headaches, reduced ability to fuse at distance; difficulties in judging distances of moving objects
5%	Binocular response amplitude equal to monocular (no summation)	Marked reduction in binocular summation of contrast sensitivity	Significantly reduced distance and near stereopsis	Asthenopia, headaches, reading difficulties, ocular discomfort (e.g., eyelid twitching)
>5%	Binocular response amplitude less than monocular (binocular inhibition)	Absence of binocular summation of contrast sensitivity	No stereopsis	Diplopia/marked visual discomfort; inability to function in tasks requiring binocular vision (e.g., ball sports)

*Expressed as the percentage difference in retinal image size between the eyes [1–3].

4. Management can be challenging, as the patient must adapt not only to static differences in perceived image size but also to changes in binocular coordination resulting from spectacle-induced prismatic effects during gaze shifts.

It should be noted that although the magnitude of aniseikonia can be quantified using objective measures – such as electrophysiological assessment of binocular summation and contrast sensitivity testing – clinically relevant clues are often provided by symptoms and stereopsis findings (tab. 1). Equally important is the assessment of VISUS binocular summation.

Clinicians should be alert to situations in which best-corrected binocular visual acuity is not superior to the best-corrected monocular visual acuity of each eye measured separately. Such a finding may suggest clinically relevant aniseikonia and/or other causes of asthenopia. The accommodative reflex, an automatic response of the eye involving both the crystalline lens and the extraocular muscle system, enables clear vision at near. Importantly, accommodation is not limited to a change in lens shape but represents a coordinated physiological response involving the accommodative triad (accommodation, convergence, and pupillary constriction).

Under normal conditions, the accommodative response is bilateral and symmetrical; therefore, proper binocular balancing is essential during subjective refraction, particularly when prescribing optical correction in patients with anisometropia. In everyday clinical practice, a commonly used method of binocular balancing is dissociated fogging (Humphriss/modified fogging technique), which can be performed using a phoropter or in free space with a trial frame. The accommodative reflex (accommodative triad) consists of three components:

1. Accommodation of the crystalline lens – contraction of the ciliary muscle reduces zonular tension, allowing the lens to become more convex and increase its refractive power, thereby focusing near images on the retina.
2. Pupillary constriction (miosis) – improves depth of focus and reduces optical aberrations by limiting peripheral light rays.
3. Convergence – both eyes rotate nasally so that the visual axes align on the same near target.

The primary stimulus for accommodation is a shift in fixation from a distant to a near object. This change initially produces retinal defocus (blur), which triggers a neural response. Visual information is transmitted from the retina via the optic nerve to the visual cortex, where it is processed and integrated. Subsequently, efferent signals are relayed to the midbrain accommodation centers and to the oculomotor complex (cranial nerve III), resulting in activation of the ciliary muscle, the pupillary sphincter, and the medial rectus muscles.

Myopia progression can be reduced using both pharmacological interventions (e.g., atropine eye drops) and optical strategies. Optical approaches to myopia control are vision correction methods designed not only to provide clear vision but also to slow axial elongation of the eyeball, which represents the principal structural mechanism underlying myopia progression. The following common characteristics of optical myopia control methods can be distinguished:

1. Their primary aim is to modify peripheral retinal defocus (i.e., shift peripheral focus towards a more myopic position), thereby reducing the stimulus for axial elongation of the eye.
2. The greatest benefit is typically achieved when treatment is initiated early, as soon as progressive myopia is detected.
3. Optical interventions are usually combined with lifestyle recommendations, including increased outdoor time (approximately ≥2 h per day) and regular breaks during prolonged near work.

Basic recommendations applicable to most optical myopia control methods include:

1. Treatment should be initiated early, ideally as soon as progressive myopia is detected.
2. Optical interventions should be combined with adjunctive lifestyle modifications, including increased outdoor time (≥2 h/24 h) and regular breaks during prolonged near work (e.g., every 15–20 min, as a modification of the 20–20–20 rule commonly used in young adults).

Among optical methods, three main approaches can be distinguished (summarized in table 2):

1. Spectacle lenses incorporating myopic defocus, such as Defocus Incorporated Multiple Segments (DIMS) or similar technologies. Examples include MiYOSMART (HOYA) and Stellest (Essilor) [4–6].
2. Multifocal soft contact lenses (MFSCLs) designed for myopia control. A representative example is MiSight® 1 day (CooperVision), which uses ActivControl® technology [7].
3. Orthokeratology (Ortho-K)– overnight wear of rigid gas-permeable contact lenses. Although no single proprietary design is used, the underlying principle is to induce relative peripheral myopic defocus while correcting central vision [8, 9].

In patients with anisometropia, careful refraction should be performed both before and after cycloplegia, as even mild accommodative spasm or asymmetrical accommodative effort may influence refractive measurements and may potentially affect myopia progression and binocular visual function.

Example:

A 6-year-old child presents with the following refractive findings:
Right eye (OD): +0.25 D (manifest, pre-cycloplegia) and +1.50 D (post-cycloplegia).
Left eye (OS): −3.25 D (manifest, pre-cycloplegia) and −1.50 D (post-cycloplegia).
After autorefraction, subjective refraction was confirmed using a trial lens set (trial frame refraction).
In this scenario, failure to fully correct the hyperopic error in the right eye may lead to persistent accommodative effort in both eyes, which can artificially increase the apparent myopic refractive error in the left eye. Under such conditions, optical myopia control strategies may fail to achieve their intended peripheral myopic defocus effect due to sustained accommodative strain. Consequently, inadequate correction may contribute to further refractive progression in one eye and may also increase the risk of persistent or newly developing amblyopia in the fellow eye.
Another important consideration is the relatively early introduction of contact lens correction in patients presenting with clinically significant symptoms of aniseikonia. However, due to daily wear-time limitations of soft contact lenses, they do not fully replace the need for spectacle correction, including spectacle-based myopia control technologies. A similar limitation applies to orthokeratology (Ortho-K), as temporary discontinuation may occur (e.g., intercurrent illness, lens loss, or lens damage). In such circumstances, an appropriate back-up optical correction is necessary.
Early implementation of contact lens correction is particularly relevant because multiple aspects of visual function and visual perception continue to develop in early childhood. Insufficient similarity of retinal images between the eyes may prevent stable sensory fusion and appropriate simultaneous perception. Clinically, this may result in suppression and/or dominance of one eye during selected visual tasks, especially under conditions that favor the better-performing eye.

Example:

A 28-year-old patient with childhood aniseikonia who did not receive contact lens correction failed to develop stereopsis and currently demonstrates alternating fixation. The right eye (OD) is emmetropic (0.00 D) and is preferentially used for distance vision. The left eye (OS) has an uncorrected refractive error of −4.25 D and is predominantly used

TABLE 2

Optical methods for managing myopia progression.

Method	Mechanism of action	Effectiveness (average)	Advantages	Limitations / disadvantages
DIMS spectacle lenses	Central optical zone corrects refractive error, while peripheral lens segments induce peripheral myopic defocus, reducing the stimulus for axial elongation	~50–60%	Easy to prescribe and use; safe; suitable for children (typically ≥6 years); low risk of complications	Higher cost than standard spectacles; requires full-time wear
Multifocal soft contact lenses (MFSCLs)	Multizone optical design with central correction and peripheral zones inducing myopic defocus	~30–50%	Effective; natural visual field; suitable for active children	Requires daily hygiene and handling; higher cost than spectacles; risk of ocular inflammation/infection with inadequate care
Orthokeratology (Ortho-K)	Overnight wear of rigid gas-permeable lenses reshapes the cornea; daytime unaided vision; peripheral optics induce relative myopic defocus	~40–60%	No need for daytime correction; effective also in moderate myopia	High cost; strict hygiene required; risk of microbial keratitis; regular specialist follow-up needed

DIMS – Defocus Incorporated Multiple Segments; MFSCL – Multifocal Soft Contact Lenses.

for near vision. This pattern may be reinforced by optical factors related to undercorrection of myopia, which can increase the relative clarity and/or perceived size of near objects compared with full correction.

It should also be noted that long-standing binocular imbalance may be associated with suppression of one eye, the development of a suppression scotoma, and/or reduced best-corrected visual acuity.

A key element in the management of anisometropia is comprehensive assessment of binocular vision and visual perception, typically performed by optometrists. In anisometropia, monocular visual function and binocular cooperation may be compromised due to spectacle-induced prismatic effects and/or sensory processing adaptations. Therefore, in addition to providing appropriate optical correction with spectacles or contact lenses, ongoing monitoring of binocular vision parameters and proactive visual rehabilitation and patient education are recommended.

These measures aim to enable early detection of clinically relevant aniseikonia, accommodative–convergence dysfunction, impaired stereopsis, and associated oculomotor abnormalities that may coexist with anisometropia. Effective interdisciplinary communication between the ophthalmologist and optometrist– and, in pediatric patients, also the pediatrician and often educational professionals (e.g., teachers, pedagogues, or school psychologists)– is essential. Visual impairment can substantially affect a child's spatial functioning and academic performance.

CORRESPONDENCE
Joanna Przeździecka-Dołyk, MD, PhD
Clinic of Ophthalmology, Medical University of Wroclaw
50-556 Wrocław, ul. Borowska 213
e-mail: joanna.przezdziecka.dolyk@gmail.com

ORCID
Joanna Przeździecka-Dołyk – ID – https://orcid.org/0000-0002-1099-4876

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Conflict of interest:
None.
Financial support:
None.
Ethics:
The content presented in the article complies with the principles of the Helsinki Declaration, EU directives and harmonized requirements for biomedical journals.

