



Spectacle correction of anisometropia following cataract surgery

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ABSTRACT

Optical correction after cataract surgery is an important issue, especially after intraoperative complications or experiencing refractive prediction error. Patients with these issues often have anisometropia and symptoms of aniseikonia. Also, optical anisophoria

should be carefully corrected in these cases. Here we discuss and analyze the most common clinical situations which clinicians can encounter and outline the individual approach in each scenario.

KEY WORDS: cataract surgery, anisometropia, spectacle correction, prismatic effect.

INTRODUCTION

Modern cataract surgery is one of the safest, most effective, and frequently executed surgical procedures in ophthalmology performed today [1, 2]. Around 300 000 cataract surgical procedures refunded by the National Health Fund (NFZ) are performed yearly in Poland starting from 2017 [3].

The vast majority of cataract operations produce excellent visual outcomes, which improve the quality of life of patients [4, 5]. It has to be noted that significant binocular vision impairments rarely present after cataract surgery [6], and most (72.7%) biometry prediction errors are within the ± 0.5 D range. However, in specific postoperative conditions, problems with binocular vision caused by anisometropia may occur. One of them is refractive prediction error – “refractive surprise”, described as error higher than ± 2.0 D, reported by Lundström *et al.* in 3555/282 811 cases [7]. Another problem affecting binocular vision is postoperative aphakia, and high refractive error in the non-operated eye [8].

Spectacles are the most common, non-invasive, optical correction of ametropia. Like any method they have advantages, disadvantages, and limitations of use.

The intended refractive result of cataract surgery is usually the improvement of uncorrected distance visual acuity (implantation of monofocal intraocular lens [IOL] calculated for emmetropia). However, in selected clinical situations, IOL power is calculated for near (e.g. in myopic eyes). An IOL placement can imitate the physiological condition of phakia, but it does not entirely eliminate patients' need to use spectacles or contact lenses. Residual refractive error and/or insufficient refractive power for near vision often require

a correction. Moreover, many patients endure anisometropia after cataract treatment. This condition produces the differential prismatic effect in spectacles (anisophoria) and unequal spectacle magnification (aniseikonia). These issues may cause patient distress and difficulties with everyday tasks. However, there is individual tolerance of anisophoria and aniseikonia. Patients not tolerating the mentioned effects will experience asthenopia symptoms and binocular vision problems. Due to limited vertical fusional reserve capacity, the vertical differential prism may cause not only asthenopia symptoms (vertical differential prism more than 1 PD [9]) but, in some cases, double vision. Due to ocular prism adaptation, tolerance of differential prism in a horizontal direction may be higher than 5 PD, as described by Henson and North [10].

ANISOMETROPIA

This condition occurs when eyes have different refractive power and, as a result, different corrective lenses, and the difference is greater than 1.00 D [11, 12]. Woodhouse showed that a difference more than 1.00 D between eyes should be considered abnormal [13]. Patients with uncorrected anisometropia can present significant problems such as diplopia, eyestrain, headaches, and suppression [14]. There are two types of anisometropia: axial, which is attributed to the interocular difference in axial length, and refractive, when the refractive power of the two eyes is unequal, e.g., because of difference in corneal curvature. It can also be categorized into five types according to existing refractive errors: simple myopic (one eye myopic and the other emmetropic); compound myopic (both eyes myopic); simple hypermetropic (one hy-

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permetropic eye and the other emmetropic); compound hypermetropic (both eyes hypermetropic); and antimetropic (one eye myopic and the other hypermetropic) [15]. Correction of anisometropia is the most common cause of induced aniseikonia. Furthermore, when the eyes look away from the optical center of the lenses, it can create anisophoria [16]

ANISEIKONIA

Aniseikonia occurs when the visual images of the two eyes are different in size, shape, or both [14]. Katsumi *et al.* stated that only a 3.0% difference in the perceived retinal image could be tolerated by the binocular system [17]. Campos and Enoch's studies showed that when aniseikonia is greater than 5% it can cause a loss of stereopsis [18]. The most common symptoms of aniseikonia are presented in Table I [19].

There are two methods of measuring aniseikonia: a direct comparison method and a space eikonometric method. The direct comparison method compares the sizes of the images of the two eyes directly [20]. There are at least two tests available: the conventional new aniseikonia tests (NAT) [21] and the Aniseikonia Inspector (AI) [22]. The principle of these tests is that a different size target is presented to each eye. The person who performs the examination uses lenses in front of one of the patient's eyes until the two size targets are equal. The other method is that the patient physically changes the size of one target [23]. The space eikonometric measurement is based on the fact that the two eyes perceive different sizes of the images because of the perception of anomalous spatial patterns [20]. A typical instrument used in the eikonometric method is the space eikonometer [24]. This procedure has high precision and accuracy but the maximum aniseikonia that can be measured is 5% [20].

KNAPP'S LAW

Knapp's law states whether contact lenses or spectacles are best for aniseikonia.

The use of contact lenses for refractive aniseikonia and spectacles for axial aniseikonia is a clinical application derived from Knapp's law [25, 26].

Table I. Symptoms of aniseikonia [19]

Symptoms of aniseikonia	Prevalence (%)
Headaches	67
Asthenopia	67
Photophobia	27
Reading difficulty	23
Nausea	15
Motility	11
Nervousness	11
Vertigo and dizziness	7
General fatigue	7
Distortion in spatial perception	6

The formula used for calculation of the difference of image size expected in the transition to contact lenses can be simply estimated:

$$P_{CT} = P_{SP} - d * \Delta F'_v$$

where $\Delta F'_v$ (in D) is the anisometropic difference; d is corneal vertex distance (in cm); P_{SP} is the aniseikonia (in %) measured in vision testing at the corneal vertex distance d ; P_{CT} is the aniseikonia (in %) expected in the transition to contact lenses [25].

Kramer *et al.* concluded that in clinical practice, Knapp's law has limitations in applicability in patients with high myopia due to a reduction in retinal element density [27].

OPTICAL ANISOPHORIA

Optical anisophoria is a type of heterophoria in which the amount varies with the direction of gaze. It may appear in anisometropic spectacle correction when the eyes look in different directions of gaze. It can cause a prismatic effect that induces phorias [14].

Prentice's rule can simply estimate the magnitude of the prismatic effect:

$$P = c * F$$

where P is a prismatic effect Δ [prism diopter]; c [cm] is distance in centimeters from the optical center, F [diopter D] is power of the lens [28].

In the case when a patient has correction (RE): +3.00 D (LE): +6.00 D, the difference between the eyes is 3.00 D. The prismatic effect at a point that lies 5 mm (0.5 cm) below the optical center of a +3.00 D lens is $P = 0.5 * 3.00 = 1.5 \Delta$ base up (BU) but for a +6.00D lens is: $P = 0.5 * 6.00 = 3 \Delta$ base up (BU). The base direction of the prismatic effect in these two corrections can be found by visualizing where the thickest portion of the lens is, and in the plus lens, it lies at the optical center – this induced vertical differential prism is shown in Figure 1.

Henson and North stated that eyes can adapt to a vertical differential prism when worn permanently [10]. However, we have to remember that this is not a comfortable situation for an anisometrope where visual points are moving within the

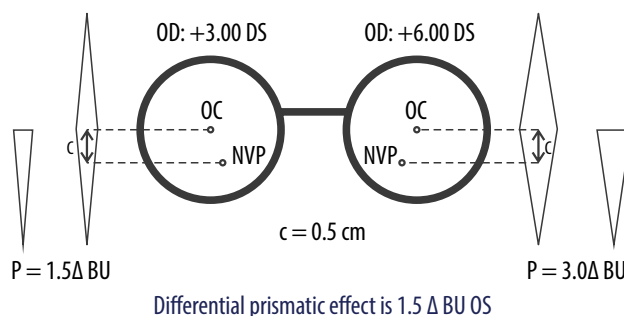


Figure 1. Optical anisophoria. The differential prismatic effect at near visual points (NVP) depends on the difference in refractive power and distance c between optical centers (OC) and (NVP)

lens as the eye rotates. These patients expect good binocular single vision at all times [28].

ANALYSIS OF POSSIBLE CLINICAL SCENARIOS

Anisometropia after cataract surgery is not an uncommon situation, especially in the case of unilateral extraction. Some potential clinical situations are described below:

Example 1. Intraoperative posterior capsule rupture with no intraocular lens implantation resulting in postoperative aphakia. The incidence of capsular rupture during cataract surgery is low (in high-income countries the frequency is 1-2% [29]), but the consequence of this complication could be unilateral optical aphakia. It is one of the most severe forms of refractive anisometropia. Correction with spectacle lenses leads to optical aniseikonia of approximately 25-30% magnification of the retinal image (assuming that the other eye is emmetropic and depends on corneal vertex distance). Such a difference in image size will impair fusion and is likely to suppress the image of the weaker eye. In order to reduce the retinal image size, the corrective lens should be located as close as possible to the eye's principal plane.

When providing secondary implantation of IOL is contraindicated, the most suitable solution is using a contact lens, which reduces the difference in size between the retinal images to a few percent and permits the most natural vision [30].

Example 2. Postoperative anisometropia of 3.00 D between the eyes. It is essential to know how corrective lenses change the size of the retinal image. A rule of a thumb is that for every single D of corrected anisometropia 1% of the image size difference is induced [31]. Oguchi and Mashima demonstrated that if aniseikonia is in the range 3-5%, binocular summation and stereopsis are possible [32]. Hence the conclusion is that four diopters of corrected anisometropia are acceptable for most patients.

Spectacle correction of 3.00 D anisometropia seems to be acceptable for most patients because the image size difference is about 3%. However, it has to be emphasized that the vertical differential prismatic effect at a near visual point located 1 cm away from the optical center of spectacle single vision lenses is 3 PD. This vertical prism may produce diplopia at near visual points. Hence, patients wishing to use glasses for reading (one of the essential activities for elderly people) have to adjust the head and gaze direction to minimize the prismatic effect in spectacles. An individual approach is needed, which requires close cooperation between an ophthalmologist or optometrist and optician to solve this problem. Sometimes special centration of single vision lenses is recommended. Patients who use bifocal lenses have to use segments located in the decentered zone of lenses. Inconveniently, vertical imbalance reduction by change of position of gaze or reading material is impossible; therefore, introduction of prism compensation is often required. Another way to overcome induced differential prism in bifocals is by pairing two lenses with different segments (e.g., one lens with a round segment, the second with a flat-top segment). However, this solution may be cosmetically unacceptable. Fortunately, on the optical market, new iseikonic and isophoric ophthalmic lens designed for single vision, bifocal and progressive addition lenses are available.

Example 3. Anisometropia and monovision after the cataract surgery. Patient's preoperative refractive error: RE: -3.00 D; LE: -3.00 D. Before the unilateral cataract removal, the person can choose to have a satisfactory uncorrected distance visual acuity in the operated eye. The physician needs to calculate the IOL to obtain emmetropia after the operation. Assuming that the postoperative refraction of the operated eye is -0.25 D, and the other eye is myopic (-3.00 D), it means that one eye has good visual acuity for far and the other eye for near vision without any optical aids. This situation is called monovision and causes a differential blur between the eyes. A conventional procedure is required to determine ocular dominance preoperatively. IOL calculated for emmetropia will be implanted in the dominant eye and IOL calculated with myopic shift in the nondominant eye. Good visual outcomes have also been observed in an alternative procedure called crossed monovision (when the dominant eye is used for near activities). Monovision is a more valuable option for elderly patients with weak ocular dominance [33]. Usually, when patients accept monovision, the visual system suppresses the lower-quality image and processes the higher quality image. It is vital to know that monovision degrades stereo acuity and contrast sensitivity [34, 35]. Blur differences cause an illusion that makes patients dramatically misperceive the distance and three-dimensional direction of moving objects and may cause difficulties while driving [36]. Despite these drawbacks, many people can adapt to monovision correction.

CONCLUSIONS

There is no commonly accepted approach to manage aniseikonia. Scheiman and Wick recommend considering various factors when deciding about aniseikonic correction [37].

In order to successfully manage anisometropia at least the following tests should be performed: visual acuity (distance and near), cover test, Worth test, Maddox test, stereovision test, and an eikometric test. If the patient does not report any subjective problems, the particular aniseikonic correction is not needed. On the other hand, patients who feel relief from asthenopic symptoms while covering one eye, and those who experience intolerance with any other correction, should wear aniseikonic correction. In these cases, special aniseikonic lenses would be beneficial.

Essential factors to consider when correcting anisometropia following cataract surgery include magnitude (degree) of anisometropia, magnitude (degree) of aniseikonia and image size differences, visual acuities, presence of suppression of patient's eye, individual tolerance of vertical differential prism, and individual ability to maintain fusion retinal images of different sizes.

There is no simple rule allowing us to choose a threshold value for anisometropia correction with glasses in patients after cataract surgery. Corrective glasses' power selection should be the result of a careful examination of aniseikonia tolerance. An individual approach to every clinical situation and the cooperation of eye health care providers are essential.

DISCLOSURE

The authors declare no conflict of interest.

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