https://doi.org/10.5114/oku/207087 (Research Paper)

Received: 21.04.2025 Accepted: 30.04.2025

Challenges in attaining optimal visual outcomes in patients with high myopia

Łukasz Kempys[1,2], Ewa Mrukwa-Kominek[3,4]

[1] Department of Ophthalmology, Regional Specialist Hospital No. 2 in Jastrzębie-Zdrój, Poland
Managing Physician of the Department of Ophthalmology: Paweł Stala, PhD, MD
[2] Okulus Plus Center for Ophthalmology and Optometry in Bielsko-Biała, Poland
[3] Chair and Clinical Department of Ophthalmology, Faculty of Medical Sciences in Katowice, Medical University of Silesia in Katowice, Poland
Head: Professor Dorota Wyględowska-Promieńska, PhD, MD
[4] Department of Adult Ophthalmology, Kornel Gibiński University Clinical Center, Medical University of Silesia in Katowice, Poland
Head: Professor Dorota Wyględowska-Promieńska, PhD, MD

Summary: Myopia is most commonly associated with the need for refractive correction, but it carries substantially more serious clinical implications. In the course of high myopia, pathological changes within the eye are considerably more frequent. They may hinder or even preclude the attainment of full visual acuity, despite correctly performed surgical interventions. This study aims to analyze the key diagnostic and therapeutic challenges involved in achieving optimal visual outcomes in patients with high myopia.

Key words: high myopia, degenerative myopia, myopic maculopathy, intraocular lens calculation in high myopia, laser vision correction in high myopia, phakic intraocular lenses.

Introduction

Myopia is considered a lifestyle-related disease, and its prevalence is increasing worldwide, especially in highly developed countries. The modern lifestyle of young individuals – marked by prolonged near-work, limited outdoor activities, and ubiquitous use of electronic devices requiring sustained visual focus – has significantly worsened this public health issue. The Beaver Dam Eye Study from the USA, dating back to the late 1980s, already demonstrated a rising myopia prevalence trend over recent decades. In the presented study, the problem of myopia affected only 14.8% of individuals over 65 years of age, 25.1% of individuals aged 55–64 years, and as many as 42.9% of individuals aged 43–54 years [1, 2]. In 2020, the estimated prevalence of myopia was 32.2% among the population in Eastern Europe, 34.6% in Central Europe, and 36.7% in Western Europe. At the same time, myopia was found to have a prevalence of 51.6% among the East Asian population [3]. Grzybowski's study on school-aged children found that myopia prevalence was 73% among students in East Asia, 42% in North America, and less than 10% in Africa and South America [4]. It is projected that by 2050, myopia will affect 49.8% of the global population, with high myopia affecting 9.8% [5].

The etiopathogenesis of myopia is influenced by the coexistence of genetic and environmental factors. The presence of myopia, especially in both parents, significantly increases the risk of early-onset myopia in children [3]. Environmental factors known to predispose individuals to the development of this refractive error include excessive near-work due to intensive school education, prolonged use of electronic devices during leisure time, limited outdoor activity, and reduced exposure to daylight [3, 6, 7].

High myopia is defined as a refractive error with a spherical equivalent greater than -6.0 D and an axial eye length exceeding 26.0 mm [8]. It may be associated with degenerative myopia – a condition affecting the entire eye, where excessive mechanical stretching of the tissues leads to the development of structural changes. Beyond challenges in correcting the refractive error itself, it also correlates with other ocular pathologies [8, 9]. Despite various correction methods – both conservative and surgical – pathological myopia often presents a clinical challenge, complicating the achievement of satisfactory visual acuity.

Implications of high myopia

One of the most common complications of high myopia is the presence of maculopathy. A meta-analysis by Shi et al., involving patient groups from four continents, found that myopic maculopathy affects up to 49% of individuals with high myopia. In the general population, the prevalence of maculopathy is 1.7% [10]. During the course of the condition, the retina takes on a mosaic-like appearance due to the progressive thinning of the retinal pigment epithelium and irregular foci of atrophy. The emerging areas of chorioretinal atrophy lead to the formation of scotomas in the visual field and deterioration of central vision. Due to the pathological elongation of the eye, the optic disc (CN II) is often obliquely shaped and features the so-called 'myopic conus' caused by retinal pigment epithelium (RPE) atrophy and exposure of the sclera (Fig. 1). These changes also lead to the development of scotomas in the visual field.

The so-called 'lacquer cracks' are breaks within the RPE, Bruch's membrane, and the choriocapillaris. They occur in approximately 5% of patients with pathological myopia. Choroidal neovascularization (CNV) may develop in their area [8, 11]. CNV is a serious complication of high myopia, as it can significantly impair central vision. It is estimated that 5–10% of patients with degenerative myopia are affected. Despite treatment with anti-VEGF injections, foci of scarring or atrophy often develop, resembling geographic atrophy seen in the dry form of age-related macular degeneration (AMD) (Fig. 2). At sites of previous neovascularization, foci of RPE hyperplasia may form – the so-called 'Fuchs spots' [8, 11, 12].

ISSN 1505-2753

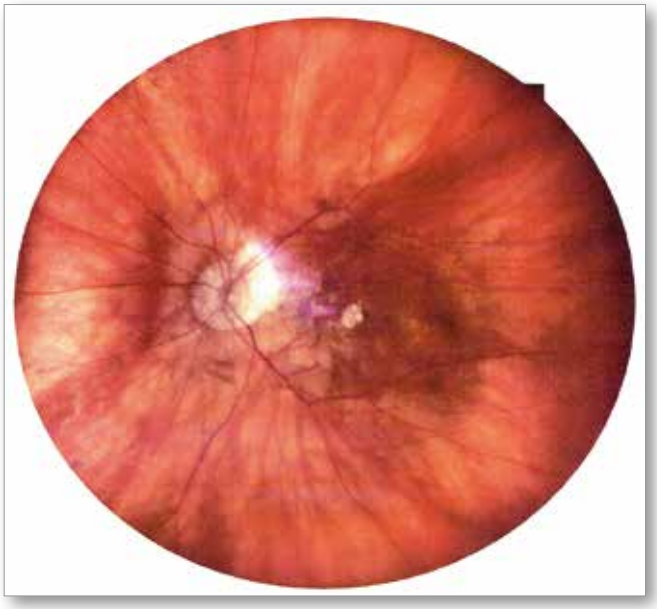

Fig. 1. Presence of myopic conus and macular chorioretinal atrophy in a patient with high myopia.

Approximately one-third of patients with degenerative myopia develop posterior staphyloma due to thinning and stretching of the posterior sclera. It most commonly affects the macular region or the optic disc (CN II), significantly increasing the risk of retinal detachment and macular holes (Fig. 3) [11, 13].

In patients with high myopia, a statistically significant increase in the incidence of rhegmatogenous retinal detachment has been observed. Excessive axial elongation of the eye leads to increased retinal stretching, making it more susceptible to peripheral retinal tears. Additionally, the vitreous body in elongated eyes is more prone to collapse and detachment from the retina, which also elevates the risk of retinal tear formation. Studies show that the risk of retinal detachment is five to six times higher in individuals with high myopia compared to those with low myopia [14, 15]. In turn, Ludwig et al. showed that the incidence of rhegmatogenous retinal detachment in phakic patients with degenerative myopia in the United States is 39 times higher than in patients without myopia, while the incidence in myopic individuals is three times higher compared to non-myopic individuals [16]. The literature reports a significant increase in the risk of rhegmatogenous retinal detachment following cataract surgery in patients with high myopia compared to emmetropic individuals [16–18].

In their meta-analysis, Marcus et al. demonstrated that myopia increases the risk of developing primary open-angle glaucoma. Patients with high and moderate myopia had a 50% higher risk of developing the disease compared to patients with low myopia [14, 19].

Younan et al. identified a statistically significant link between myopia and cataract development. The results of the study indicate that posterior subcapsular cataracts are more commonly observed in individuals with any degree of myopia, whereas nuclear cataracts occur significantly more frequently in patients with high myopia [14, 20].

The enumerated conditions can significantly affect final visual acuity, even after refractive error correction, and pose a significant challenge in the long-term care of myopic patients.

During the assessment of eligibility for intraocular lens implantation in patients with high myopia, difficulties may arise in accurately calculating the lens power. The problem arises from the discrepancies between the results obtained using different calculation formulas, which can lead to undercorrection or overcor-

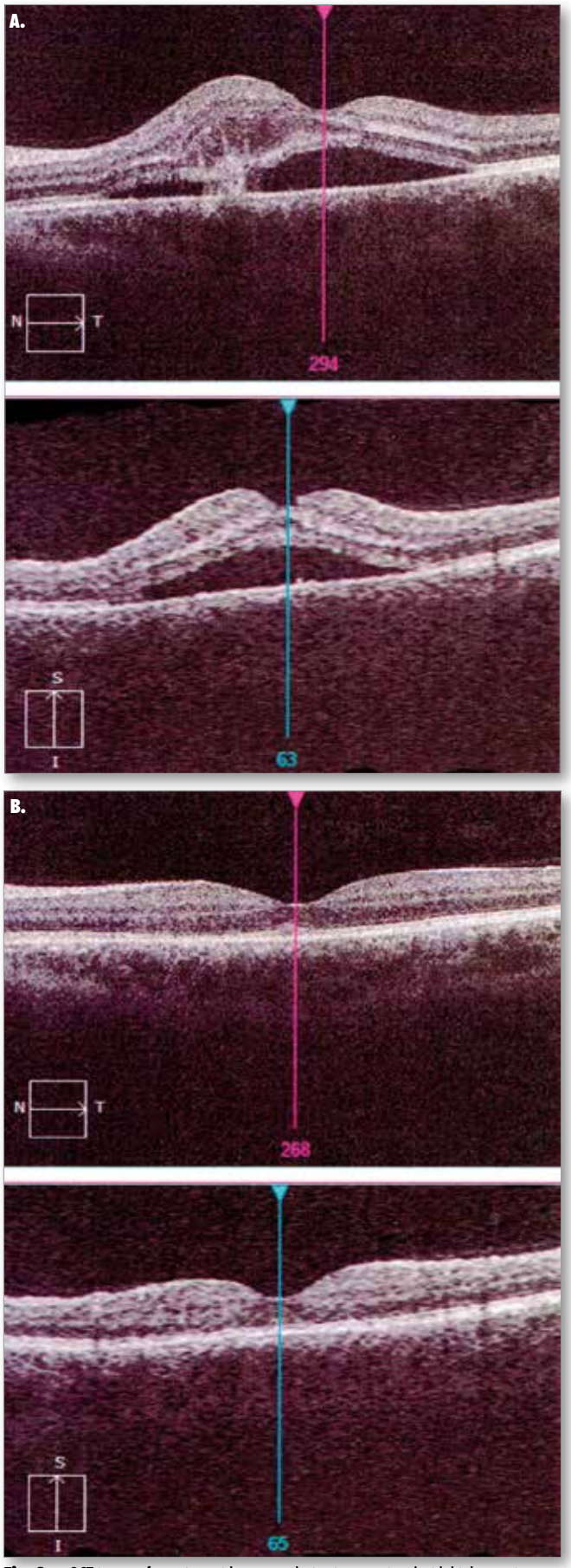

Fig. 2. OCT image of a patient with neovascularization associated with high myopia – A. before treatment, B. after a single intravitreal anti-VEGF injection.

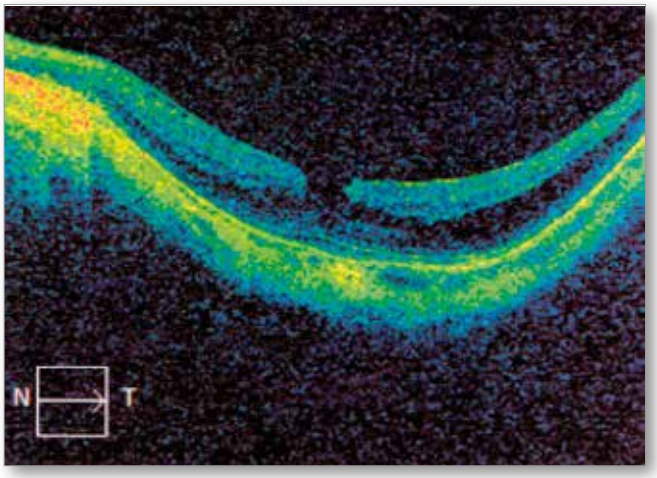

Fig. 3. Lamellar macular hole in a patient with high myopia.

rection of the refractive error. An elongated eye influences both axial length measurement and the estimation of the effective lens position, a crucial factor in IOL power calculation. The calculation formulas employ advanced artificial intelligence algorithms. However, even so, the results obtained for the same patient may vary in the case of atypical parameters of axial eye length. In their study, Melles et al. compared the accuracy of intraocular lens power calculation formulas (Barrett Universal II, Haigis, Hoffer Q, Holladay 1, Holladay 2, Olsen, and SRK/T) in predicting postoperative refractive outcomes. The presented data indicate that the SRK/T formula shows reduced accuracy in eyes with atypical corneal curvature: both very flat and steep. The Hoffer Q and Olsen formulas demonstrate clear prediction errors correlated with anterior chamber depth, with each formula showing biases in opposite directions. In contrast, the Haigis formula is the most sensitive to variations in the thickness of the natural lens. Among all the power calculation formulas compared, the Barrett Universal II formula exhibits the smallest predictive deviations, irrespective of variations in axial eye length, keratometry, anterior chamber

OD right — **IOL calculation** — **OS** left

Eye status

OD (right)	OS (left)
LS: Phakic	LS: Phakic
VS: Vitreous body	VS: Vitreous body
Ref: ---	Ref: ---
VA: ---	VA: ---
LVC: Untreated	LVC: Untreated
LVC mode: -	LVC mode: -
Target ref.: +0.00 D	Target ref.: +0.00 D
SIA: +0.00 D @ 0°	SIA: +0.00 D @ 0°

Biometric values

OD (right)		OS (left)	
AL: 34.58 mm (!)	SD: 26 µm	AL: 31.58 mm	SD: 6 µm
ACD: 2.71 mm	SD: 5 µm	ACD: 2.90 mm	SD: 5 µm
LT: 4.93 mm (!)	SD: 70 µm	LT: 4.79 mm	SD: 25 µm
WTW: 12.3 mm		WTW: 12.3 mm	
SE: 41.69 D	SD: 0.03 D	SE: 42.07 D	SD: 0.01 D
K1: 41.13 D @ 12°		K1: 40.94 D @161°	
ΔK: -1.14 D @ 12°		ΔK: -2.33 D @161°	
K2: 42.26 D @102°		K2: 43.27 D @ 71°	
TSE: ---		TSE: ---	
TK1: ---		TK1: ---	
ΔTK: ---		ΔTK: ---	
TK2: ---		TK2: ---	

K Alcon AcrySof SN 60 AT — Haigis (A0: -0.111 A1: +0.249 A2: +0.179)

IOL (D)	Ref (D)
-2.50	-0.71
-3.00	-0.39
-3.50	**-0.08**
-4.00	+0.24
-4.50	+0.55
-3.62	Emmetropia

K Alcon AcrySof SN 60 AT — SRK®/T (A const.: 118.80)

IOL (D)	Ref (D)
-3.00	-0.55
-3.50	-0.24
-4.00	**+0.07**
-4.50	+0.38
-5.00	+0.68
-3.88	Emmetropia

K Alcon AcrySof SN 60 AT — Haigis (A0: -0.111 A1: +0.249 A2: +0.179)

IOL (D)	Ref (D)
+2.50	-0.64
+2.00	-0.31
+1.50	**+0.01**
+1.00	+0.34
+0.50	+0.66
+1.52	Emmetropia

K Alcon AcrySof SN 60 AT — SRK®/T (A const.: 118.80)

IOL (D)	Ref (D)
+2.00	-0.47
+1.50	-0.16
+1.00	**+0.16**
+0.50	+0.46
+0.00	+0.77
+1.25	Emmetropia

K Alcon AcrySof SN 60 AT — Barrett Universal II (LF: +1.78 DF: +5.0)

IOL (D)	Ref (D)
-1.50	-0.69
-2.00	-0.26
-2.50	**+0.17**
-3.00	+0.58
-3.50	+1.00
-2.31	Emmetropia

K Alcon AcrySof SN 60 AT — Hoffer® Q (pACD: +5.44)

IOL (D)	Ref (D)
-4.00	-0.55
-4.50	-0.24
-5.00	**+0.07**
-5.50	+0.37
-6.00	+0.67
-4.89	Emmetropia

K Alcon AcrySof SN 60 AT — Barrett Universal II (LF: +1.78 DF: +5.0)

IOL (D)	Ref (D)
+3.00	-0.58
+2.50	-0.24
+2.00	**+0.09**
+1.50	+0.41
+1.00	+0.73
+2.13	Emmetropia

K Alcon AcrySof SN 60 AT — Hoffer® Q (pACD: +5.44)

IOL (D)	Ref (D)
+1.50	-0.68
+1.00	-0.37
+0.50	**-0.07**
+0.00	+0.24
-0.50	+0.53
+0.39	Emmetropia

Fig. 4. Discrepancies between intraocular lens power calculation formulas: Haigis, SRK/T, Barrett Universal II, and Hoffer Q in a patient with high myopia.

ISSN 1505-2753

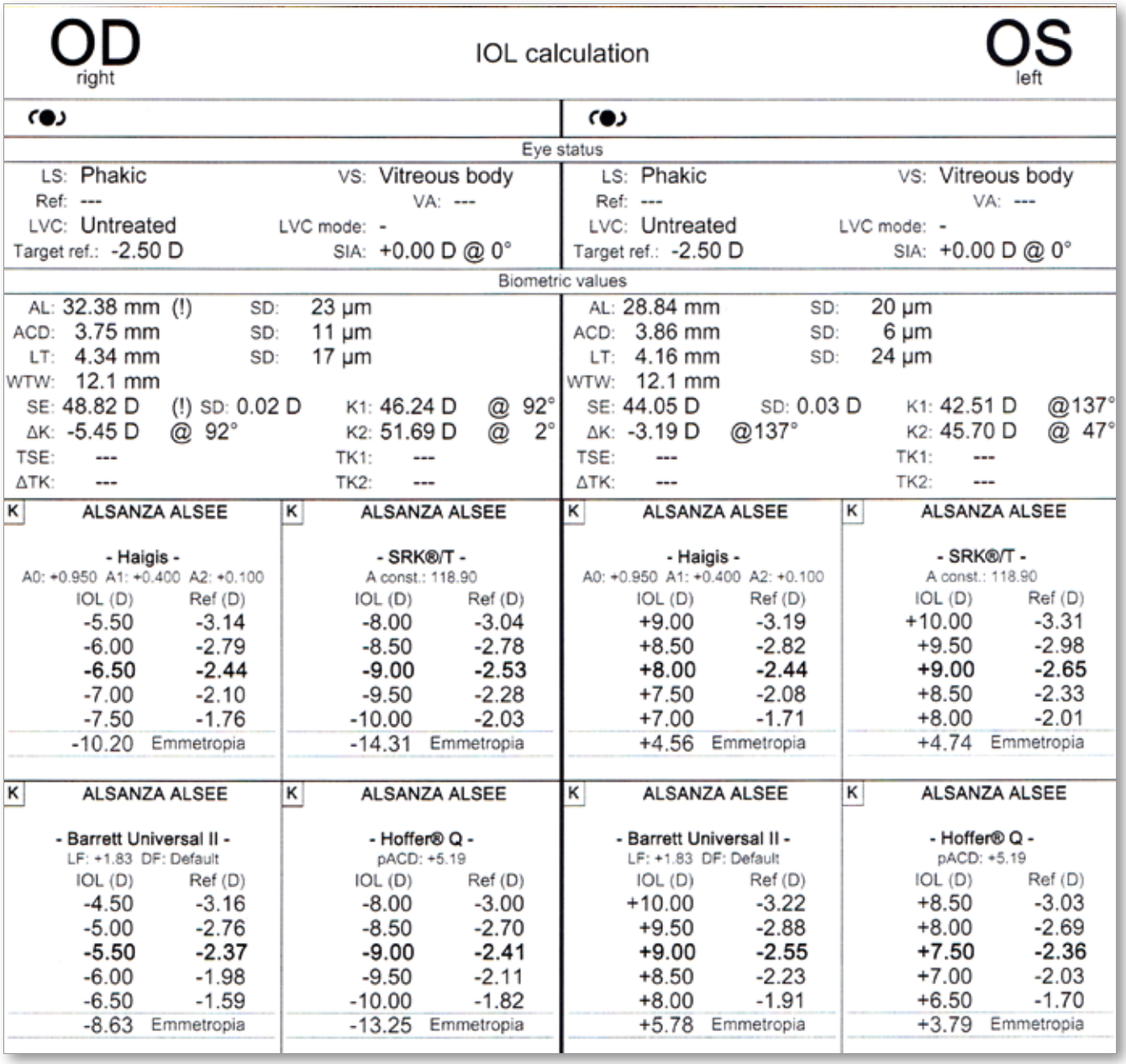

Fig. 5. Discrepancies between intraocular lens power calculation formulas: Haigis, SRK/T, Barrett Universal II, and Hoffer Q in a patient with high myopia.

depth, or lens thickness. This consistency establishes it as one of the most reliable formulas across diverse ocular anatomies [21]. Ghanem et al. found that in eyes with high axial myopia, the efficacy of the SRK/T, Hoffer Q, Holladay 2, and Haigis formulas is comparable for the implantation of low positive power lenses, whereas for negative power lenses, the Haigis formula proves to be the most precise (Fig. 4, 5) [22].

When calculating intraocular lens power in eyes with atypical anatomical parameters, it is crucial to be familiar with the available calculation formulas, their advantages and limitations, and to apply multiple methods to best match the individual structure of the eye.

Laser vision correction methods are gaining increasing popularity in the treatment of myopia. Refractive surgery is an effective alternative to conservative methods. LASIK, SMILE, and surface ablation procedures precisely reshape the curvature of the cornea, enabling proper focusing of light rays on the retina. However, the efficacy and safety of the procedures depend on corneal thickness, which must allow for the removal of an adequate amount of tissue without compromising its biomechanical integrity. Randleman et al. found that the risk of postoperative ectasia rises significantly when the percentage of compromised tissue reaches or exceeds 40% of the preoperative central corneal thickness [23]. According to the recommendations issued by leading ophthalmological societies, in the case of deeper procedures, the postoperative stromal bed should be at least 250 µm thick. Consequently, patients with low corneal thickness may not be eligible for surgery (Fig. 6) [24].

If laser vision correction is not an option for myopia treatment, an alternative is the implantation of phakic intraocular lenses. In recent years, there has been a marked increase in the number of intraocular procedures performed. These interventions enable the correction of very high refractive errors while preserving the patient's natural accommodation and allowing for a rapid return to daily activities [24]. In their meta-analysis, Barsam et al. demonstrated that over a one-year follow-up, phakic intraocular lenses were comparably effective and offered greater safety than laser vision correction methods in patients with myopia ranging from –6 to –20 D [25]. In turn, Moshirfar et al. demonstrated

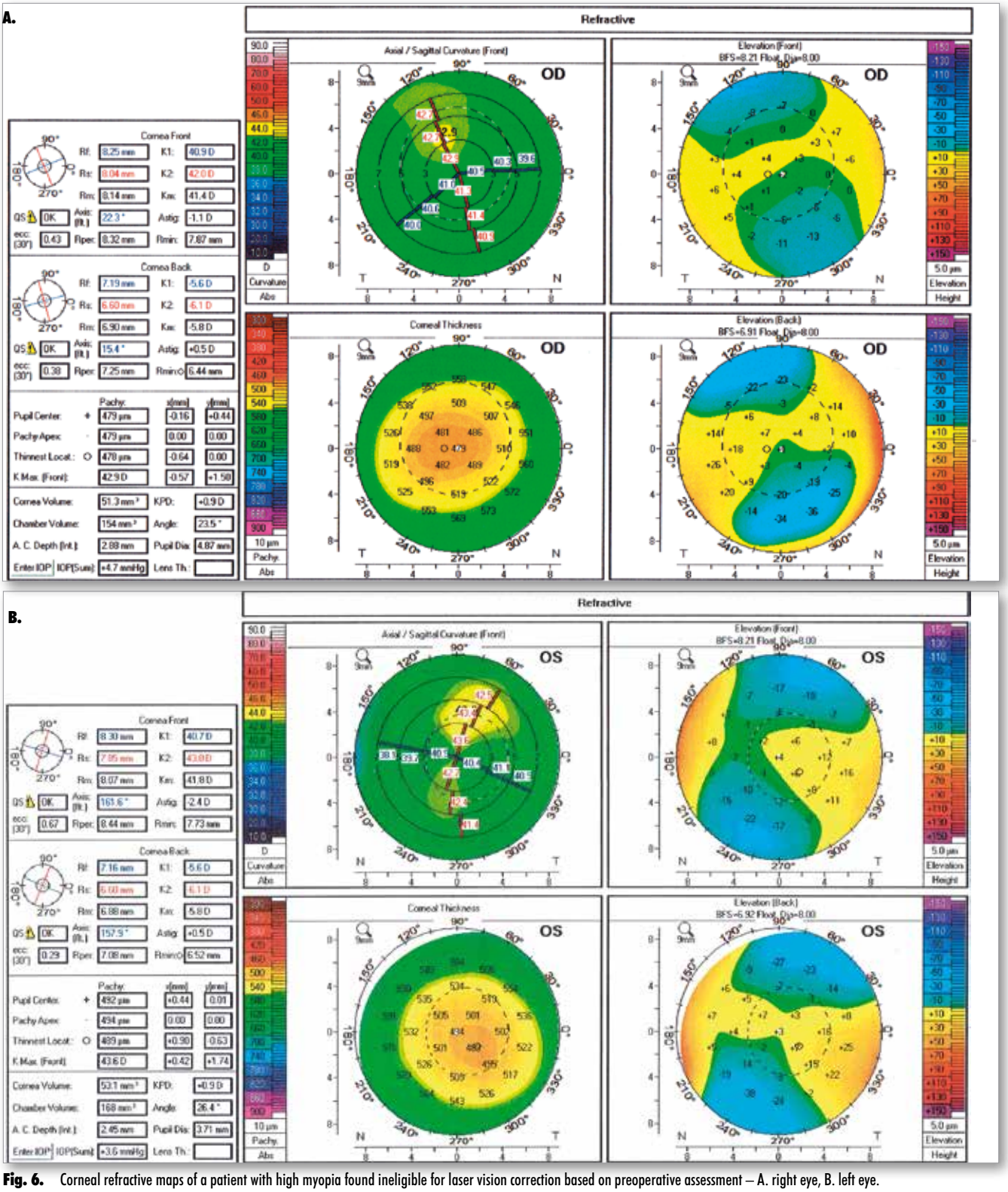

Fig. 6. Corneal refractive maps of a patient with high myopia found ineligible for laser vision correction based on preoperative assessment – A. right eye, B. left eye.

that the proportion of eyes with uncorrected postoperative visual acuity of 1.0 at 12 months after surgery was similar in patients who underwent phakic intraocular lens implantation and those treated with the SMILE procedure. However, a greater number of eyes in the SMILE group fell within ±0.5 D of spherical equivalent after surgery [26]. It should be noted, however, that not every patient is eligible for phakic intraocular lens implantation. Eligibility depends on factors including adequate anterior chamber depth, endothelial cell density, and the anatomy of the drainage angle. The minimum anterior chamber depth (measured from the corneal endothelium to the anterior lens capsule) must be 2.8 mm (or 3.0 mm, depending on the lens type); the refractive error must remain stable within ±0.5 D for one year, and an adequate endothelial cell density is required, depending on the patient's age. Implantation of a phakic intraocular lens is associated with an increased risk of anterior subcapsular cataract, greater endothelial cell density loss, and the development of pigmentary glaucoma [24, 27, 28].

ISSN 1505-2753

Conclusions

High myopia presents a significant challenge for ophthalmologists – not only in diagnostics, treatment planning, and conservative and surgical therapy, but also in the management of complications. The unusual anatomical parameters of the eye and associated comorbidities in patients with high myopia necessitate an individualized approach and particularly meticulous management to achieve optimal visual acuity.

Disclosure
Conflict of interests: none declared
Funding: no external funding
Ethics approval: Not applicable.

References:

1. Wang Q, Klein BE, Klein R, et al.: *Refractive status in the Beaver Dam Eye Study*. Invest Ophthalmol Vis Sci. 1994; 35(13): 4344–4347. [PubMed] [Google Scholar]
2. Foster PJ, Jiang Y: *Epidemiology of myopia*. Eye (Lond). 2014 Feb; 28(2): 202–208. doi: 10.1038/eye.2013.280. Epub 2014 Jan 10. PMID: 24406412; PMCID: PMC3930282.
3. Németh J, Tapasztó B, Aclimandos WA, et al.: *Update and guidance on management of myopia. European Society of Ophthalmology in cooperation with International Myopia Institute*. Eur J Ophthalmol. 2021 May; 31(3): 853–883. doi: 10.1177/1120672121998960. Epub 2021 Mar 5. PMID: 33673740; PMCID: PMC8369912.
4. Grzybowski A, Kanclerz P, Tsubota K, et al.: *A review on the epidemiology of myopia in school children worldwide*. BMC Ophthalmol. 2020 Jan 14; 20(1): 27. doi: 10.1186/s12886-019-1220-0. PMID: 31937276; PMCID: PMC6961361.
5. Holden BA, Fricke TR, Wilson DA, et al.: *Global Prevalence of Myopia and High Myopia and Temporal Trends from 2000 through 2050*. Ophthalmology. 2016 May; 123(5): 1036–1042. doi: 10.1016/j.ophtha.2016.01.006. Epub 2016 Feb 11. PMID: 26875007.
6. Eppenberger LS, Sturm V: *The Role of Time Exposed to Outdoor Light for Myopia Prevalence and Progression: A Literature Review.* Clin Ophthalmol. 2020 Jul 2; 14: 1875–1890. doi: 10.2147/OPTH.S245192. PMID: 32669834; PMCID: PMC7337435.
7. He X, Sankaridurg P, Wang J, et al.: *Time Outdoors in Reducing Myopia: A School-Based Cluster Randomized Trial with Objective Monitoring of Outdoor Time and Light Intensity*. Ophthalmology. 2022 Nov; 129(11): 1245–1254. doi: 10.1016/j.ophtha.2022.06.024. Epub 2022 Jun 30. PMID: 35779695.
8. Bowling B: *Kanski Okulistyka kliniczna*. Wrocław: Edra Urban & Partner; 2017, s. 630.
9. Bakunowicz-Łazarczyk A, Filipek E, Hautz W: *Wytyczne dotyczące postępowania w krótkowzroczności postępującej u dzieci i młodzieży*. Polskie Towarzystwo Okulistyczne 2021.
10. Shi H, Guo N, Zhao Z, et al.: *Global prevalence of myopic macular degeneration in general population and patients with high myopia: A systematic review and meta-analysis*. Eur J Ophthalmol. 2024 May; 34(3): 631–640. doi: 10.1177/11206721231185816. Epub 2023 Jul 12. PMID: 37439028.
11. Ueta T, Makino S, Yamamoto Y, et al.: *Pathologic myopia: an overview of the current understanding and interventions*. Glob Health Med. 2020 Jun 30; 2(3): 151–155. doi: 10.35772/ghm.2020.01007. PMID: 33330799; PMCID: PMC7731360.
12. Neelam K, Cheung CM, Ohno-Matsui K, et al.: *Choroidal neovascularization in pathological myopia*. Prog Retin Eye Res. 2012 Sep; 31(5): 495–525. doi: 10.1016/j.preteyeres.2012.04.001. Epub 2012 Apr 28. PMID: 22569156.
13. Ohno-Matsui K, Jonas JB: *Posterior staphyloma in pathologic myopia*. Prog Retin Eye Res. 2019 May; 70: 99–109. doi: 10.1016/j.preteyeres.2018.12.001. Epub 2018 Dec 8. PMID: 30537538.
14. Williams K, Hammond C: *High myopia and its risks*. Community Eye Health. 2019; 32(105): 5–6. PMID: 31409941; PMCID: PMC6688422.
15. Flitcroft DI: *The complex interactions of retinal, optical and environmental factors in myopia aetiology.* Prog Retin Eye Res. 2012 Nov; 31(6): 622––660. doi: 10.1016/j.preteyeres.2012.06.004. Epub 2012 Jul 4. PMID: 22772022.
16. Ludwig CA, Vail D, Al-Moujahed A, et al.: *Epidemiology of rhegmatogenous retinal detachment in commercially insured myopes in the United States*. Sci Rep. 2023 Jun 9; 13(1): 9430. doi: 10.1038/s41598-023-35520-x. PMID: 37296124; PMCID: PMC10256775.
17. Neuhann IM, Neuhann TF, Heimann H, et al.: *Retinal detachment after phacoemulsification in high myopia: analysis of 2356 cases*. J Cataract Refract Surg. 2008 Oct; 34(10): 1644–1657. doi: 10.1016/j.jcrs.2008.06.022. PMID: 18812113.
18. Lin J-Y, Ho W-L, Ger L-P, et al.: *Analysis of factors correlated with the development of pseudophakic retinal detachment - A long-term study in a single medical center*. Graefes Arch Clin Exp Ophthalmol. 2013; 251: 459–465. doi: 10.1007/s00417-012-2043-3.
19. Marcus MW, de Vries MM, Junoy Montolio FG, et al.: *Myopia as a risk factor for open-angle glaucoma: a systematic review and meta-analysis*. Ophthalmology. 2011 Oct; 118(10): 1989–1994.e2. doi: 10.1016/j.ophtha.2011.03.012. PMID: 21684603.
20. Younan C, Mitchell P, Cumming RG, et al.: *Myopia and incident cataract and cataract surgery: the blue mountains eye study*. Invest Ophthalmol Vis Sci. 2002 Dec; 43(12): 3625–3632. PMID: 12454028.
21. Melles RB, Chang WJ: *Accuracy of Intraocular Lens Calculation Formulas*. Ophthalmology. 2018 Feb;125(2):169-178. doi: 10.1016/j.ophtha.2017.08.027. Epub 2017 Sep 23. PMID: 28951074.
22. Ghanem AA, El-Sayed HM: *Accuracy of intraocular lens power calculation in high myopia*. Oman J Ophthalmol. 2010 Sep; 3(3): 126–130. doi: 10.4103/0974-620X.71888. PMID: 21120048; PMCID: PMC2992159.
23. Randleman JB, Woodward M, Lynn MJ, Stulting RD. *Risk assessment for ectasia after corneal refractive surgery*. Ophthalmology. 2008 Jan; 115(1): 37–50. doi: 10.1016/j.ophtha.2007.03.073. Epub 2007 Jul 12. PMID: 17624434.
24. Wierzbowska J: *Kompendium Nowoczesnych Metod Korekcji Wad Wzroku*. Warszawa: Biblioteka Lekarza Praktyka; 2020, s. 64.
25. Barsam A, Allan BD: *Meta-analysis of randomized controlled trials comparing excimer laser and phakic intraocular lenses for myopia between 6.0 and 20.0 diopters*. Cornea. 2012 Apr; 31(4): 454–461. doi: 10.1097/ICO.0b013e31823f0b29. PMID: 22236791.
26. Moshirfar M, Somani AN, Motlagh MN, et al.: *Comparison of FDA-Reported Visual and Refractive Outcomes of the Toric ICL Lens, SMILE, and Topography-Guided LASIK for the Correction of Myopia and Myopic Astigmatism*. J Refract Surg. 2019 Nov 1; 35(11): 699–706. doi: 10.3928/1081597X-20190930-01. PMID: 31710371.
27. Huang D, Schallhorn SC, Sugar A, et al.: *Phakic intraocular lens implantation for the correction of myopia: a report by the American Academy of Ophthalmology.* Ophthalmology. 2009 Nov; 116(11): 2244–2258. doi: 10.1016/j.ophtha.2009.08.018. PMID: 19883852
28. Spaeth Gl, Danesh-Meyer HV, Goldberg I: *Chirurgia okulistyczna, wydanie czwarte*. Wrocław: Edra Urban & Partner; 2012, s. 191–196.

Reprint requests to:
Łukasz Kempys, MD (e-mail: m2g@onet.eu, katedra.okulistyki@uck.katowice.pl)
Okulus Plus Centrum Okulistyki i Optometrii
Górska 19, 43-300 Bielsko-Biała