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Case Report

IOL Power Calculation in an Unusual Long Fellow Eye: A Case Report

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Abstract: Background: Intra-Ocular Lens (IOL) power calculation in long eyes remains challenging despite the availability of new formulas and biometers. This case report shows that optimization of the A-constant in the first eye can reduce postoperative refractive error in the second eye, even in the case of an IOL with negative power. This report aimed to describe a case in which this method was used to calculate IOL power to reduce postoperative refractive error in a long fellow eye. As far as we know, this is the first paper reporting the use of the optimized constant in the first eye to reduce postoperative error in the second eye in the case of a negative IOL. Case presentation: A highly myopic patient with nuclear cataracts underwent phacoemulsification cataract surgery (PCS) in both eyes. The axial length (AL) was 39.42 mm in the right eye and 37.45 mm in the left eye. All biometric data were obtained via low-coherence reflectometry using an OA-2000 biometer (Tomey, Nagoya, Japan). First, an IOL power calculation using the Barrett II formula and PCS was performed in the shorter eye. To evaluate the postoperative refractive error, the optimized A-constant in the left eye was estimated using the Camellin-Calossi formula. The new A-constant was then used for the right eye IOL power calculation using the same formula. The prediction error (PE) in the left eye was -0.23 D with the Barrett II formula. The optimized A-constant method using the Camellin-Calossi formula in the fellow eye gave −0.28 D of PE. Conclusions: The A-constant optimization for very long eyes, using data from the first operated eye, may be useful to reduce refractive prediction error in the second eye in very long eyes, as well as in the case of IOL power with negative values.

Keywords: a-constant optimization; IOL power calculation; Camellin-Calossi formula; fellow eye

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1. Introduction

Before cataract surgery, choosing the correct Intra-Ocular Lens (IOL) power and the most suitable formula based on patient parameters is a key point in surgical planning. Therefore, many studies have been conducted to identify the most appropriate biometric formula based on the eye to operate on [1–3]. It is known that the vitreous component in very long eyes is greater than that in normal eyes; therefore, it follows an axial length (AL) measurement error resulting from the incorrect use of the eye's global refractive index [4]. New-generation formulas (e.g., Kane, Barrett II, and Holladay 2) consider this error, which underrates IOL power and generates hyperopic errors using traditional ones. Different correction factors for AL were adopted to correct the old-generation formula. Wang and Koch proposed an AL linear optimization system that depends on the biometer and the formula used [5]. The same was made in the Holladay 2 formula; however, the optimization is polynomial and not linear [6]. Nowadays, there are no valid online calculators for eyes with very long AL, since for long eyes, Barrett II, Kane, and Pearl DGS ones arrive at 38 mm, 35 mm, and 39 mm, respectively, while third-generation formulas (e.g., SRK/T, Holladay 1, and Camellin-Calossi) give hyperopic errors. Chikako et al. published the results of the Camellin-Calossi formula for virgin eyes [7]. The aim was to show how it was possible, in this case report, to reduce the refractive error in the fellow eye, knowing the postoperative data obtained from the first eye in the case of negative IOL power. Thus, the error is intrinsically linked to the third-generation biometric formula.

2. Case Presentation

This report describes a 50-year-old, highly myopic male patient with nuclear cataracts (N4C1P1 according to the LOCS-III grading system [8]) in both eyes. The preoperative data are shown in Table 1. This case was conducted at the University Hospital of Messina in compliance with the principles of the Declaration of Helsinki. Written informed consent was obtained from the patient for the publication of details of their medical data and accompanying images. Table 2 shows that the third-generation formula would produce hyperopic errors. Several formulas provide no result (N/A) because of the limitations in the input variables of the online calculators. All biometric data were obtained using a low-coherence reflectometry OA-2000 biometer (Tomey, Nagoya, Japan), and the measurements for each eye were repeated three times. The patient underwent phacoemulsification cataract surgery (PCS) in both eyes with a refractive target of 0 D for business needs. The implanted IOL in both eyes was a RayOne Aspheric (Rayner Intraocular Lenses Ltd., Worthing, UK), with an optimized A-constant of 118.7, according to www.iolcon.com (accessed on 1th September 2021). The nominal optical biometry constant A (manufacturer-recommended lens constants) is a theoretical mean value that represents the average position of the IOL within the eye of a given IOL model (variable depending on design and material). This value is generally suggested by the manufacturer and does not have a metric unit. Optimized lens constants based on the different biometers are searchable on the website. Some surgeons use these lens constants as a starting point rather than the manufacturer-recommended ones.

Table 1. Preoperative data.

Data	Right Eye	Left Eye
MRSE (D)	−24.75	−23
CDVA (logMAR)	0.2	0.2
Kavg (D)	41.21	41.61
ACD (mm)	3.07	3.16
LT (mm)	4.30	4.25
AL (mm)	39.42	37.45
CCT (μm)	551	556
WTW (mm)	12.12	12.06
Constant A	118.7	118.7

MRSE = mean refraction spherical equivalent; CDVA = corrected distance visual acuity; Kavg = K-readings; ACD = anterior chamber depth; LT = lens thickness; AL = axial length; CCT = central corneal thickness; WTW = white to white.

Table 2. IOL power calculations using different formulas.

IOL Formula	Right Eye	Left Eye
Barrett (limit AL = 38 mm) *	N/A	−6 D (target: +0.23)
Kane (limit AL = 35 mm) *	N/A	N/A
EVO (limit AL = 38 mm) *	N/A	−7 (target: +0.23)
Pearl DGS formula (limit AL = 40 mm) *	−10 D (target: −3.06)	−10 D (target: −1.60)
Hoffer QST (limit AL = 32 mm) *	N/A	N/A
Panacea (limit AL = 36 mm)	N/A	N/A

Camellin-Calossi formula for virgin eye	−10.16 D (target: 0)	−8.29 D (target: 0)
SRK/T	−9.97 D (target: 0)	−8.18 D (target: 0)

N/A = not applicable; * = online calculators.

Table 2 reports IOL calculations in both eyes using an idoneous formula for long eyes (online calculators) and old-generation ones, such as Camellin-Calossi (developed in an Excel sheet) and SRK/T. Therefore, many formula calculations were enabled by the AL value limitations imposed by many online calculators. Therefore, it was decided to operate on the shorter eye first, implanting a −6 D IOL power, as suggested by Barrett II [9]. At three months, the patient was emmetropic, with corrected distance visual acuity (CDVA) logMAR 0.1 and planospherical equivalent refraction using trial frames. Therefore, the prediction error (PE) in the first eye was −0.23 D. The optotype used was an ETDRS at 4 m with a background luminance of 85 cd/m^2. The ambient light was around 100 lx (photopic conditions).

For the right eye, it was not possible to obtain satisfactory results using the most reliable formula, as shown in Table 2. Therefore, it was decided to optimize the A-constant for the first eye and exploit it for the second. To do this, the Camellin-Calossi formula [10] for virgin eyes, which directly uses the A-constant, was used. Calculations that allowed for the optimization of the A-constant for the first eye, knowing the implanted IOL, postoperative refractive error, and the biometric formula used, are shown in Figure 1. In summary, the optimized A-constant was obtained by reversing the biometric formula, inserting the data of the first eye as variables, and leaving the A-constant unknown. The optimized A-constant for the first eye was 110.87. This value does not correspond to the real IOL position but to an A-constant value, which is an unreal result obtained by hyperopic error using the Camellin-Calossi formula in the first eye with negative IOL power. The IOL to be implanted in the fellow eye was then calculated using the Camellin-Calossi formula but using the optimized A-constant of the first eye. The calculated IOL power was −7.43 D, as reported in Table 3. The IOL-implanted power was −8 D (predicted postoperative refraction: +0.53 D). Three months after PCS, postoperative subjective refraction in the second eye was +0.25 D (CDVA = 0.1 logMAR), with high patient satisfaction. Therefore, the predicted refractive error (spectacle plane) was only −0.28 D, owing to this method. Simultaneously, the use of other available biometric formulas would have provided hyperopic errors, as shown in Table 2.

Table 3. Postoperative data and calculation for the fellow eye.

	Right Eye (Fellow Eye)	Left Eye (First Eye)
IOL power implanted (D)	−8	−6
Postoperative MRSE (D)	+0.25	0
CDVA (logMAR)	0.1	0.1
Second eye calculation (Pearl DGS formula) *	N/A	
Second eye calculation (Optimized A-constant method using the Camellin-Calossi formula) (D)	−7.43 (target: 0 D)	

MRSE = mean refraction spherical equivalent; CDVA = corrected distance visual acuity; N/A = not applicable because of limited IOL power implanted in the first eye (negative power); * = online calculator.

Conversion of K_{AVG} into estimated corneal power using fictitious n (1.3319):

Equation 1 → $K(mm) = 0.3375/\mathbf{K(D)} = 8.11$

Equation 2 → $K_{CAMELLIN}(D) = \left(0.3319/(K(mm))\right) * 1000 = 40.91$

Intermediate calculations:

Equation 3 → $M = (0.3319/(KCamellin + \mathbf{MRSE}) * 1000 = 8.11$

Equation 4 → $C = \mathbf{AL} + 0.2 = 37.65$

Equation 5 → $B = -C - (4 * M) = -70.09$

Equation 6 → $Y = \left(((4 * M - C) * 1336)/\mathbf{P}\right) - 4 * C * M = -63.34$

Final calculations:

Equation 7 → $ELP(mm) = \left(-B - \sqrt{B^2 + 4 * Y}\right)/2 = 0.90$

Equation 8 → $N = \begin{cases} \text{IF AL } > 26\text{ mm}, N = 26 \\ \text{IF AL } \leq 26\text{ mm}, N = \mathbf{AL} \end{cases}$

Equation 9 → $ACDP_{BINKORST}(mm) = (23.45 * ELP)/N = 0.81$

Equation 10 → $ACDP_{CAMELLIN\text{-}CALOSSI}(mm) = \begin{cases} \text{IF } \mathbf{LT} < 5\text{mm} \begin{cases} \text{IF } \mathbf{ACD} < 3\text{ mm}, ACDP = ACDPBinkorst - 0.3 \\ \text{IF } 3 \leq \mathbf{ACD} < 3.5\text{ mm}, ACDP = ACDPBinkorst + 0 \\ \text{IF } \mathbf{ACD} \geq 3.5\text{ mm}, ACDP = ACDPBinkorst + 0.3 \end{cases} \\ \text{IF } \mathbf{LT} \geq 5\text{mm} \begin{cases} \text{IF } \mathbf{ACD} < 3\text{ mm}, ACDP = ACDPBinkorst + 0 \\ \text{IF } 3 \leq \mathbf{ACD} < 3.5\text{ mm}, ACDP = ACDPBinkorst + 0.2 \\ \text{IF } \mathbf{ACD} \geq 3.5\text{ mm}, ACDP = ACDPBinkorst + 0.4 \end{cases} \end{cases}$

Equation 11 → Optimized A − constant of first eye to use in second eye = $(ACDPCamellinCalossi + 63.896)/0.5836 = 110.87$

Where:
K(D)= Keratometry average of first eye
ACD (mm)= Anterior Chamber Depth of first eye
LT (mm) = Lens Thickness of first eye
AL (mm) = Axial Length of first eye
P (D) = IOL power implanted in first eye
MRSE (D) = postoperative refraction first eye

Figure 1. Optimization of the IOL A-constant for the Camellin-Calossi formula. The optimized A-constant of the first eye (for the Camellin-Calossi formula) was used for the calculation in the second eye using the Camellin-Calossi formula. The equations shown in the figure are the mathematical steps to obtain the optimized constant in the first eye and, thus, use it in the fellow eye. To optimize the constant, the biometric Camellin-Calossi formula was reversed; therefore, the constant A of the implanted IOL was unknown. The power of the implanted IOL (P) and the postoperative refraction achieved at three months (MRSE) were used as variables.

3. Discussion

The accuracy of IOL power calculation can be improved by optimizing the IOL A-constant, which should be calculated based on the IOL model, biometer, and formula used [11]. In the case of positive IOL power in myopic eyes, the third-generation formula may lead to hyperopic errors; thus, the optimized A-constant is higher than the nominal A-constant. Conversely, in short eyes, the optimized A-constant was lower than the nominal A-constant, leading to myopic errors. Therefore, Zheng et al. proposed a method to modify the A constant based on the AL changing [12]. In the case of a negative IOL, the A-constant has a non-real value, as shown in Figure 1. Therefore, by implanting an IOL of negative power using the vergence formula, if the constant is lower, the IOL power will be less negative.

The IOL power calculation method used in this report was simple and effective. This approach has been proposed in the literature, but not for lenses with negative power [13,14]. Based on the enantiomorphism of the two eyes, it was possible to more precisely estimate the IOL power of the fellow eye. In our patient, the first eye's optimized A-constant was 110.87, an unreal value that shows that the Camellin-Calossi formula yields a hyperopic error in very long eyes (37.45 mm). By maintaining the same formula but changing the A-constant, we obtained a correction factor that led to a reduction in the postoperative hypermetropic error in the second eye. We described a case using a specific method to calculate IOL power to reduce postoperative refractive error in the fellow eye for very long eyes. We believe that this system is adopted by the Pearl DGS formula [15] (second eye option—online calculator), but it does not work with negative lenses. This method may seem complicated (Figure 1), but it is possible to use systems, such as the "goal-seek" option of Excel or the online service (https://3ccalculator.lasek.it/constant-calculator/, access on 1th September 2021). Furthermore, we believe that this method would not have been necessary if we had not encountered the limitations of values in online calculators.

In general, eyes exhibit enantiomorphism; therefore, ACD, LT, and AL often have very similar values unless anisometropia is present. Anisometropia caused by axial length between two long eyes in the same patient can commonly occur. This means that a formula, such as Camellin-Calossi, can be used for this method in cases of keratometric asymmetries between the patient's eyes. Conversely, other vergence formulas calculate the effective lens position (ELP) by considering keratometry. Therefore, estimation of the postoperative IOL position can be affected by eye asymmetry in the corneal curvature.

This method may also be applied to third-generation formulas, depending on patient features. Holladay 1, SRK/T, Hoffer Q, and Shammas use different parameters to estimate ELP; therefore, they may be used when LT and ACD between the two eyes are different. In contrast, they considered K1 and K2; therefore, with curvature asymmetry, the Camellin-Calossi formula can be used. Unfortunately, the Haigis formula uses a complex system of three variables, making A-constant optimization more difficult. However, significant differences in ACD and LT between the two eyes are rare and do not modify the optimized A-constant as much as AL, which remains the most influential parameter.

It is not possible to adopt a fourth-generation formula for this method because its mathematical structures are unavailable.

A limitation of this method may be the great difference in AL between the two eyes, although our patient obtained an excellent result despite an AL difference of approximately 2 mm because an AL > 26 mm does not modify the ELP, according to Binkhorst. Therefore, this method could be useful for anisometropic eyes longer than 26 mm; however, it should be studied for shorter eyes. Further surveys with a larger population will eventually confirm this proposal for IOL power calculation in the second eye in the case of an IOL with negative values. However, the main limitations of a case report refer to the limited possibility of generalizing the validity of the study and the impossibility of establishing a cause-and-effect relationship. The clinical case presented can be considered only an example and a starting point for studies and calculations in long second eyes with implantation of negative IOLs.

In conclusion, it was possible to improve the postoperative refractive outcomes of the Camellin-Calossi formula in a very long fellow eye in the reported case by knowing the biometric formula and the postoperative error in the first eye in the case of negative IOL power by reducing the error margin of the final IOL calculation.

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