Panacea IOL Calculator

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Introduction

Ocular biometry and intraocular lens (IOL) power calculations have evolved the last 70 years in the ophthalmology field, and there is still a search for the ideal method of the calculation of the IOL. During the past two decades, the obtained outcomes have improved [1], making it possible to find isolated studies in the literature, with very low absolute median errors (MAE), 0.26–0.28, and cases within a predictive error of ±0.50 D from 86.3 to 89.04% [2], great advances in biometry undoubtedly. However, these outcomes are insufficient if we take into account the current requirements on behalf of the patients and the technology with premium lenses.

When we study groups with a very large number of patients, we still find regular outcomes with median absolute errors superior to 0.310 and with percentages of eyes within the predictive error of ±0.50 D, relatively low for all studied formulas (Melles and cols. [3], Cooke and cols. [4], Kane and cols. [5], and Darcy and cols. [6] finding a MAE for different formulas studied of 0.311–0.383 (Melles) [3], 0.306–0.348 (Cooke) [4], 0.381–0.417 (Kane) [5] and 0.377–0.410 (Darcy) [6] achieving percentages that oscillate between 71.0 to 80.8% (Melles) [3], 75.1–80.6% (Cooke) [4], 66.6–72.8% (Kane) [5], and 68.1–72.0% (Darcy) [6] of cases between ±0.50 D. In other investigations, with a very representative number of eyes studied, a high percentage of patients was observed (19.4–33.4%) outside the ±0.50 D of residual error [10–12]. In the case of extreme eyes, both greater than 26 mm and smaller than 22 mm, inferior outcomes were found [3, 4].

IOL Panacea Formula and Toric Calculator

Panacea is a formula that begins its development in the year 1997, due to the difficulty experienced during the second half of the 1990s decade, in order to determine the IOL power in eyes after refractive surgery, especially after myopic refractive corrections where a growing number of hyperopic outcomes was found.

It is a theoretical vergence formula with thin lens assumption, where the position of the IOL is estimated through a trigonometric mathematical and multivariable regression method, using predictive anatomical variables, and with an emphasis on optimizing the real corneal power with several factors in order to include eyes and corneas which fall outside the norm.

To come up with the result of the power of the IOL, the method of the calculation program will require mainly three factors:

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1. The axial length (LAX).
2. The effective lens position (ELPo) estimated through multiple variables: axial length, corneal curvature, anterior chamber depth (ACD), lens thickness (LT), corneal distance (CD), and age.
3. The total corneal power (TCP), or the optimized calculation of the K, is based on the asphericity/spherical aberration, the corneal thickness, the radius of the anterior corneal curvature, the radius of the posterior corneal curvature, and the ratio between the posterior and anterior corneal curvature (P/A).

Axial Length

The LAX has undergone an optimization since the end of the 90 s, thanks to the onset of optical biometry, which led to the reduction of the standard deviation (SD) in 0.1 mm in the case of ultrasound biometry, to <0.01 mm with optical biometry [7, 8] due to its better resolution.

During the last years, this biometric factor has been improved, mainly from three points: Spike Finder or spike detection programs incorporated in the equipment in order to improve the detection of the different internal structures and allow the use of the crystalline thickness and the retina, as reliable variables in biometrical calculations. The optical biometric calculation method by the sum of its segments, (from the sum of segments) [9–12], consisting in assigning an appropriate value for the refraction index to each ocular segment, instead of using a common value for the whole eye, thus improving the measurement of each segment separately [10–12]. This may improve the refractive outcomes in large and short eyes, in some third-generation formulas such as Hoffer Q, SRK/T, and Holladay 1 and 2, but for more modern formulas such as Haigis and Okulix, it will require the modification and optimization of the intraocular lens constants or they would not improve them [10–13]. Finally, the introduction in biometric calculation, of the real measurement of the total retinal thickness, with the use of optical coherence tomography equipment (OCT). Currently, this factor is used as a fixed value, or corrected with a factor associated with the axial length [14–16], in an indirect form by third-generation formulas, and directly (within their formulas) in many of the fourth-generation formulas. The **Panacea** program includes internal correction modules for axial length and the sum of segments, through optical and regression formulas, as well as including correction factors for extreme biometrics, both for large and short eyes.

Effective Lens Position

The estimation of the effective lens position has been one of the main factors for the improvement of the outcomes in the calculation of the intraocular lens, beginning during the mid-90 s, with the onset of fourth generation formulas, and the increase of variables such as the anterior chamber depth (ACD), the crystalline lens thickness (LT), the corneal distance (CD), age, and others.

The **Panacea** platform uses the axial length, keratometry, ACD and LT variables, as predictive factors for the estimation of the effective lens position, and adds a fifth variable, the relation between the radius of the curvature of the posterior and the anterior surface of the cornea, **the P/A ratio**, to recalculate the keratometry variable in the prediction of the effective lens position. This will be applied in corneas where the P/A ratio is abnormal, in which the anterior surface has suffered a modification mainly after refractive surgery, and the P/A ratio is used to recalculate a previous simulated K, allowing for the correction of the error described by Aramberri (Double K method [17]). Using this variable allows the height of the corneal dome to keep its value as predictive factor of the effective lens position, even in abnormal corneas, automatically (Fig. 51.1).

Total Corneal Power

Besides the two factors previously described, it is imperative to highlight the importance of the third factor, the **total corneal power** in an objec-

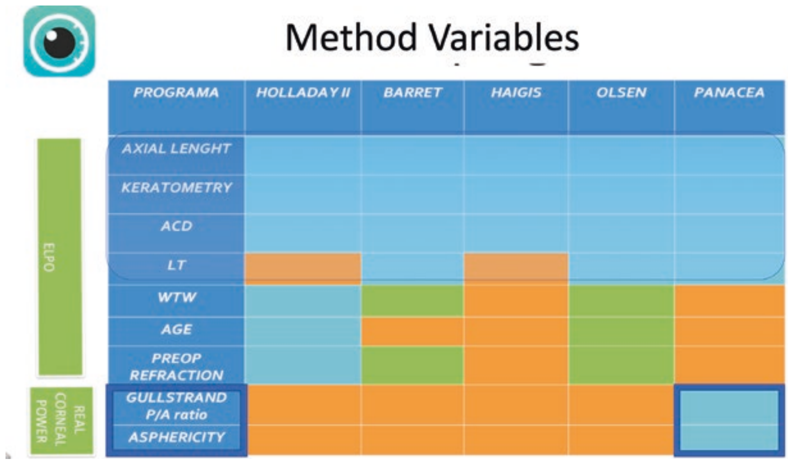

Fig. 51.1 Comparison of the variables used by different programs for the prediction of ELPo. Additional use in Panacea of the corneal asphericity and the Gullstrand ratio in order to determine the total corneal power

tive manner for the effective calculation of the IOL power, integrating two new variables to the equation, corneal asphericity and the relation between the posterior and the anterior surface of the cornea. All of this with the intent to increase the percentage of emmetropia both for cases of patients with normal corneas and for abnormal corneas (post-refractive laser, post refractive keratotomy, post-keratoplasty, keratoconus and ectasias).

This factor, the total corneal power of the cornea, and the importance of its posterior surface, has taken special relevance in the last 5 years [18, 19], mainly due to the emergence of equipment's offering approximate calculations of the total corneal power in an automatic fashion such as the total keratometry (TK) of the IOL Master 700, by ray tracing and equivalents according to Chao Pan and cols. [20] (dependents of the measured diameter) total corneal refractive power (TCRP) of the Pentacam, Mean Pupil Power (MPP) from Sirius, Total Corneal Power (TCP) from Galilei, etc.; that have been the source of study in recent investigations [21], proving its usefulness in complex cases such as Post photorefractive keratectomy-TCRP [22], Post refractive— [23–25], in Keratoconus [26–28], and in normal eyes—TK [29]. In the study of Fabian and cols. [13], it was demonstrated that both for the Haigis formula as well as for the Barrett's, using TK (Total Keratometry for IOL Master 700), increased the percentage of patients within the +/− 0.50 D in approximately 2%.

There are three corneal factors, complexes of optic mechanisms which interact among themselves, and should be understood and analyzed:

(a) The relation between the posterior and the anterior surface of the cornea.
(b) The corneal asphericity and the spherical aberration.
(c) The corneal multifocality.

Posterior-Anterior Relation/Gullstrand Ratio

For more than a century, the optical physicists, including Gullstrand, designed a strategy in order to estimate the total corneal power (due to the fact that there was only the ability to measure the anterior surface of the cornea, and with that factor alone the whole corneal power had to be calculated), they estimated a "refraction index" for the whole cornea (1.3375) [30, 31], understanding that this presupposed a fixed relation between the radius of the posterior and anterior faces of the cornea at 88%. These calculations induce an estimation error of approximately 0.68 D, due to the fact that the relation for the radius of the posterior and anterior surface (P/A rel.) for the real average cornea is 82.3%, where the estimated refraction index is more adequate at 1.3315–1.3320 [32]. This difference in the keratometry power, is corrected in the lens calculation formulas by correction factors, in some cases such as the A constant, which is why the 1.3375 index is currently being used in keratometry, presumably without any problem.

In studies with patients, it has been found that by comparing the real corneal power (measured by different equipment) against corneal power measured by the keratometry, variable outcomes have been found, always with the real corneal power being less than the one estimated by the keratometry, whose difference oscillates between 0.39 and 0.8 D [19, 27, 33–42], (see Table 51.1).

The use of values in keratometry equivalence tomographers, such as EKR (Equivalent Keratometry Reading, Pentacam equivalent keratometry), make reference to the conversion of the corneal power to a value equivalent to using a fictitious refractory index of 1.3375 on the corneal surface (Fig. 51.2).

Table 51.1 Studies showing keratometry powers vs. total corneal powers by ray tracing and comparative differences among equipment's and studied optic zones [19, 27, 33–42]

Previous studies	Year	Eyes	Km/SimK (instruments)	Total corneal power (instruments)	Difference compared with Km/SimK D (Mean ± SD)
Shirayama and associates	2010	75	43.87 ± 1.22 (IOLMasler)	43.37 ± 1.28 (Galilei, 4.0 mm)	−0.50
			43.85 ± 1.24 (atlas)		−0.48
Savini and associates	2011	43	44.04 ± 1.69 (Keraton)	43.44 ± 1.70 (Galilei, 4.0 mm)	−0.60
			43.83 ± 1.66 (Galilei)		−0.39
Savini and associates	2012	38	43.67 ± 1.45 (Keraton)	42.87 ± 1.54 (Sirius, 3.0 mm)	−0.80
			43.46 ± 1.45 (Sirius)		−0.59
Savini and associates	2013	41	43.88 ± 1.56 (Keraton)	43.22 ± 1.58 (Pentacam, 3.0 mm)	−0.68
			43.85 ± 1.59 (Pentacam)		−0.63
Saad and associates	2013	50	43 68 ± 1 68 (lOLMaster)	43.21 ± 1.32 (Pentacam, 4.0 mm)	−0.47 ± 0.34
			43.77 ± 1.33 (Pentacam)		−0.56
Seo and associates	2014	100	N/A (Petacam)	N/A (Pentacam, 4.0 mm)	0.7 ± 0.3
Oh and associates	2014	49	43.47 ± 1.02 (Pentacam)	42.76 ± 1.05 (Pentacam, 3.0 mm)	0.71
				43.13 ± 1.12 (Pentacam, 4.0 mm)	0.37
Naeser and associates	2015	951	43.42 ± 1.49 (Pentacam)	42.79 ± 1.50 (Pentacam, 3.0 mm)	0.63
				42.91 ± 1.51 (Pentacam. 4.0 mm)	0.51
Savini and associates	2017	114	43.64 ± 1.44 (Sirius)	43.07 ± 1.41 (Sirius, 3.0 mm)	−0.56 ± 0.23
Savini and associates	2018	68	43.63 ± 1.27 (Galilei)	43.08 ± 1.21 (Galilei, TCP1)	0.55
				41.841 ± 1.18 (Galilei, TCP2)	1.79
		50	43.88 ± 1.57 (Galilei)	43.18 ± 1.53 (Galilei, TCP1)	0.70
				41.92 ± 1.46 (Galilei, TCP2)	1.96
Kimiya and associates	2018	25	43.78 ± 1.89 (Pentacam HR)	43.29 ± 1.91 (Pentacam HR, 3.0 mm)	0.49
Pan and associates	2020	74	43.06 ± 1.33 (allegro Topolyzer)	42.55 ± 1.35 (TRCP Pentacam, 4.0 mm)	−0.52 (0.26)
				42.58 ± 1.38 (MMP Sirius, 4.5 mm)	−0.48 (0.22)
				42.68 ± 0.38 (TCP Galilei, 4.0 mm)	−0.38 (0.24)

Km = Mean Keratometry; Sim K = Simulated Keratometry; TCP = Galilei, Calculated Total Corneal Power; TCRP = Pentacam, Total Corneal Refractive Power; MMP = Sirius Mean Pupillary Power at 4.5 mm

However, “the problem” is magnified in two situations.

1. In the normal population, the standard deviation of the relation between the radius of the curvature on the posterior and anterior faces of the cornea (P/A) is important (there are significant differences within the normal population) and achieves 2.4%. This means that, at 2 standard deviations, the P/A ratio oscillates between 77.5 and 87.1%, and it translates into the measure offered by the keratometry, when using the estimated index at 1.3375, could be mistaken up to 0.40 D, which would induce an error in the calculation of the lens up to 0.65 D (Fig. 51.3).
2. In abnormal corneas, such as the ones after refractive surgery, radial keratotomy, post-keratoplasty, keratoconus, and other corneal ectasias where the P/A ratio can vary even further, reaching values of up to 65% in the case

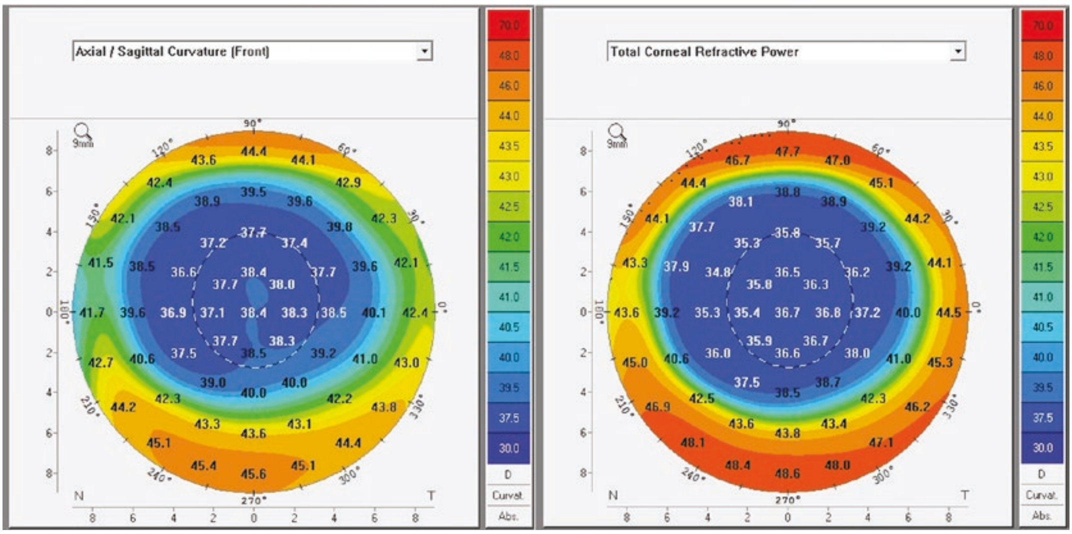

Fig. 51.2 Comparison of the corneal power measured according to the refraction index (RI) of 1.3375 (EKR) similar to keratometry and the total corneal potency

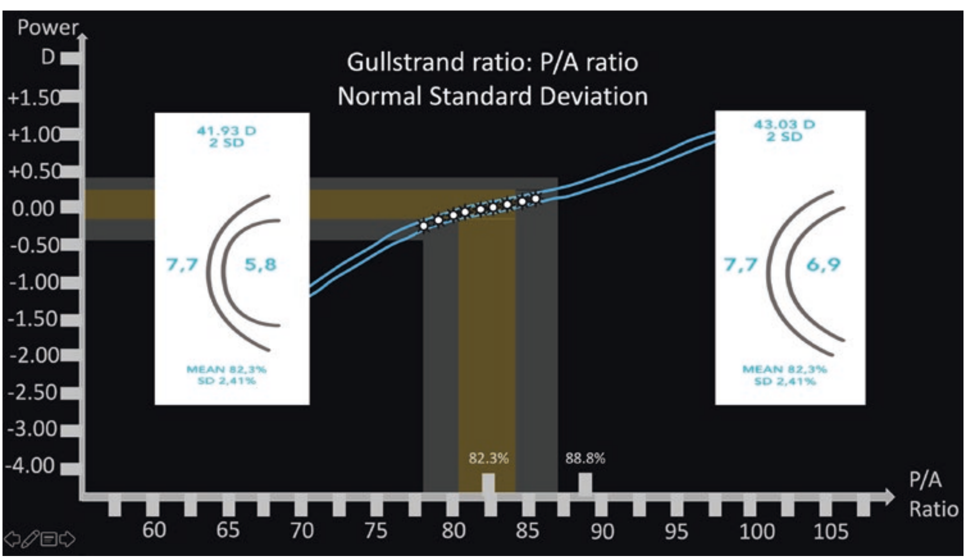

Fig. 51.3 Graph Gullstrand ratio, posterior/anterior ratio vs. gain-loss corneal power. Standard Deviation

of post-myopic, and up to 115% in the post-hyperopic refractive patient, leading into great errors in the measurement of the corneal power (that could total up to errors in the range of several diopters), on behalf of the keratometry or biometers that fail to take into account the posterior surface of the cornea (see Fig. 51.4).

When the reduction of the posterior-anterior ratio is less than 81%, as it happens after a myopic refractive surgery, induces a false over-estimation of the corneal power by the keratometry, and therefore, IOL calculation with less power, and results in a residual hyperopia. To adequately estimate the real power of these corneas, it is required to measure both radii of curvature, anterior and posterior, with a tomographer [43], in order to estimate the real diminished corneal power (Fig. 51.5).

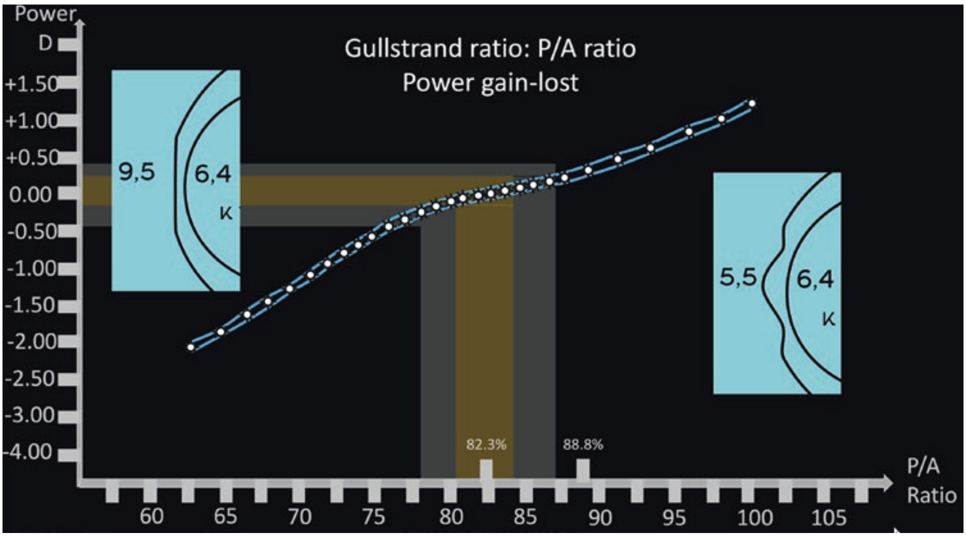

Fig. 51.4 Graph Gullstrand ratio, posterior/anterior ratio vs. gain-loss corneal power. Post-myopic, Post-hyperopic case

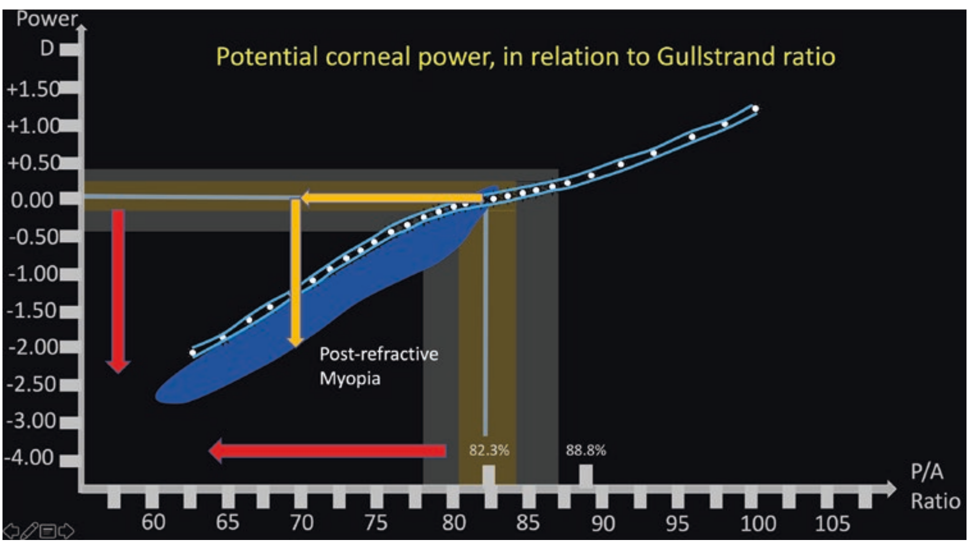

Fig. 51.5 Graph Gullstrand ratio, posterior/anterior ratio vs. gain-loss corneal power in post-myopic refractory surgery. In blue the effect induced by the asphericity, on the power measured by keratometry

Corneal Asphericity and Spherical Aberration

When we are faced with an abnormal corneal asphericity and the induction of the corneal spherical aberration, several aspects should be considered in order to understand how they can affect the estimation of the corneal power and the calculation of the IOL power.

In order to simplify the understanding of the corneal asphericity, if we use the Q term, we need to remember that a sphere has a Q value of 0. In a prolate cornea there is a peripheral flattening and Q will be negative. The human average cornea has a Q value of −0.27. In an oblate cornea the periphery will be steeper than the center and Q will be positive. In this case, as we previously stated, the keratometry which measures a more mid peripheral area, obtains a higher keratometry power than the real flatter central apical one.

Regarding the induction of spherical aberration [44], the light incidence angle in the zones that separate from the optic axis, suffers from greater refraction, making the rays focused on a more proximal point (positive spherical aberration). In a sphere, positive spherical aberration is induced. In order to avoid the induction of positive spherical aberration, a prolate aspheric lens is required (flattening towards the periphery) with a −0.58 asphericity. Since the normal cornea has a lower prolaticity than −0.27, a positive spherical aberration is induced by 0.25 μm (see Fig. 51.6).

On the contrary, in hyperopic refractive surgery, there is a trend to obtain myopic outcomes, due to the steepening of the central anterior surface, the anterior curvature radius (mm) is reduced, and therefore the P/A ratio increases in a significant manner, producing a cornea with greater relative power, than the one measured using the 1.3375 index (the keratometry underestimates the corneal power). The asphericity becomes negative, making the cornea more prolate, and there is a steepening in the center, while flattening indirectly to the periphery. This produces a measure offered by the keratometry, in its mid periphery, which is falsely flatter than the real one on its apical portion (see Fig. 51.7). Keratometry under-estimates the corneal power, and there is a tendency for myopic results.

There are two interesting cases, keratoconus cornea and corneal rings segments, where hyperopic outcomes are frequently observed after performing cataract surgeries and intraocular lens calculations with the majority of formulas, due to

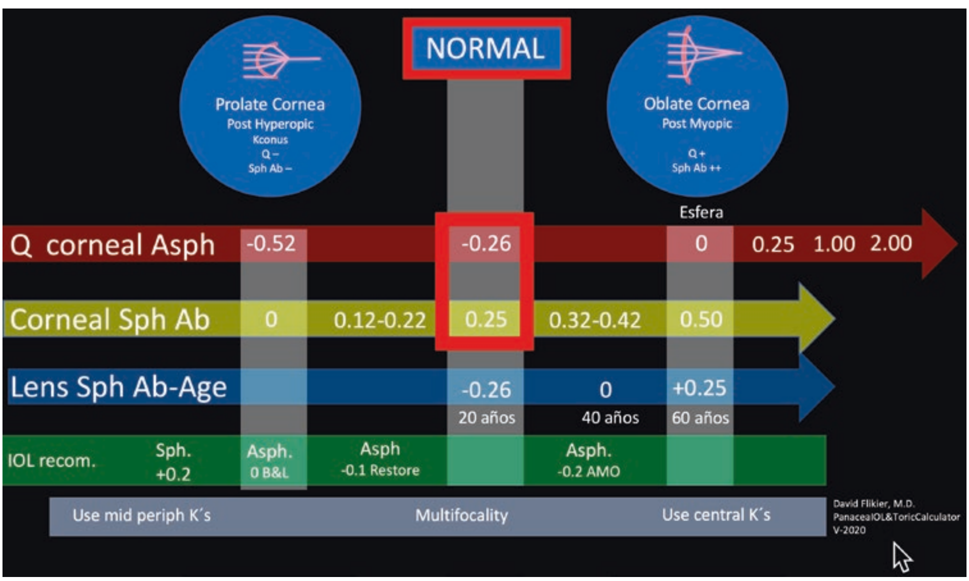

Fig. 51.6 Diagram showing the relation between the corneal asphericity (Q value), the induced aspherical aberration, and the recommended asphericity in the intraocular lens

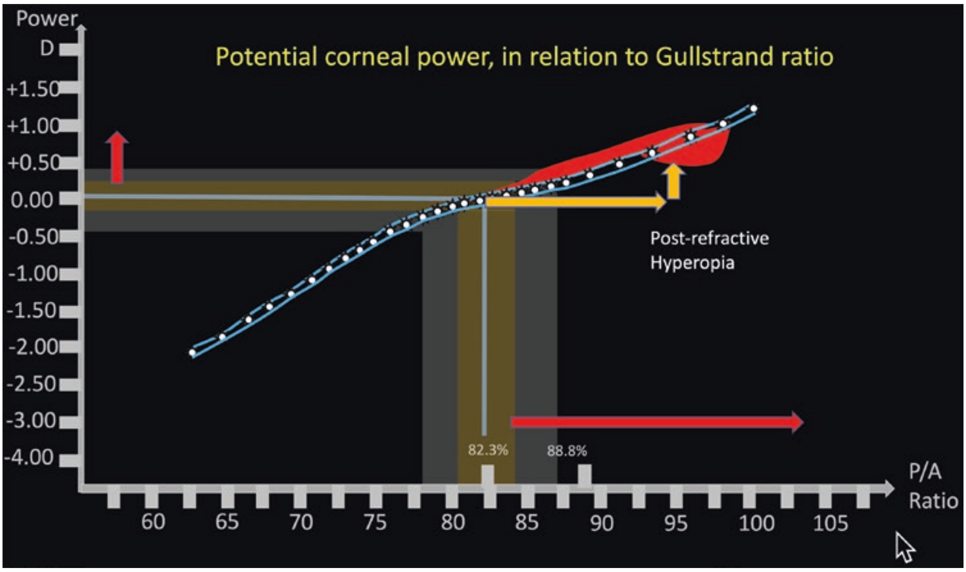

Fig. 51.7 Graph Gullstrand ratio, posterior/anterior ratio vs. gain-loss corneal power in cases of hyperopic refractive surgery

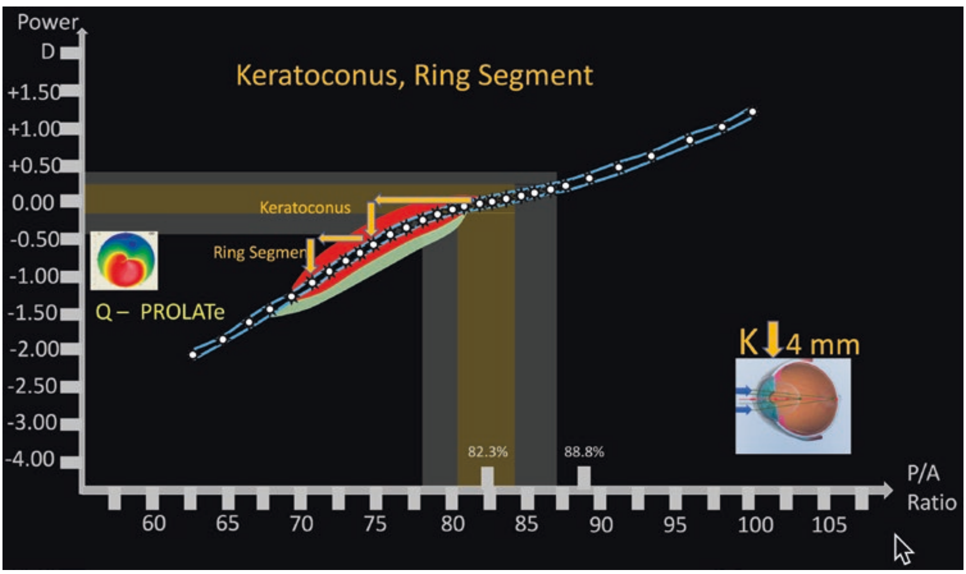

Fig. 51.8 Graph Gullstrand ratio, posterior/anterior ratio vs. gain-loss corneal power in cases with keratoconus and post corneal rings segments

the fact that these corneas present low P/A ratios, a similar effect in the total power of the cornea that appears in the post-myopic refractive surgery, but with high negative asphericities, reducing the effect of the loss of relative corneal power when measuring it with indexes of 1.3375 (see Fig. 51.8).

The last interesting case is found in corneas with marked apical flattening due to keratotomy and post-keratoplasty. In the case of keratotomies, both surfaces of the cornea have suffered flattening, with marked changes on the posterior surface, therefore the P/A relation tends to become markedly positive (differing from the laser myopic surgery). The loss of parallelism varies with penetrating and lamellar keratoplasties, according to the difference in central and peripheral thickness for the different donor discs or receptors, hence the behavior of the P/A ratio and the asphericity of each transplant, and the variability of the reports and their results (see Fig. 51.9).

Observing the relation between the posterior and anterior corneal surface and the asphericity of its anterior surface, it is possible to define the type of cornea we are facing and define the degree of diopter power gains or losses they currently have.

We need to add a fundamental factor, the one from the multifocality influence in the corneas, where the asphericity increases both towards prolaticity, such as in the oblate corneas. If we want to take advantage and maintain multifocality, by implanting the intraocular lens, we must define the power of keratometry which we will use for the calculation of the lens to be placed, so that it will allow the largest percentage of desirable near and far vision.

Corneal Multifocality

We should always consider the multifocality factor in high spherical aberrations. In multifocal corneas there will always be a zone with greater refractive diopter power, if used in an appropriate manner could be programmed for its performance for near vision, and a zone of lower refractive power that would be used for far vision.

In the eye with positive spherical aberration, with an oblate cornea, post myopic refractive surgery, if apical keratometry is used for the IOL calculation, hence for emmetropia, for far vision, the mid peripheric zones and the positive spherical aberration will have a myopization effect, allowing to provide near visual function to multifocality, mainly under mesopic conditions with greater pupillary diameter. If we want to use the multifocality of these corneas, the central apical K's must be used for far vision. This is apical keratometry for the calculations of the intraocular lens, so that the mid peripheral steeper zone would be the one providing the near-close vision. If we were to take the mid peripheral keratometries in order to calculate the intraocular lens, these zones would be the ones who would remain focused for far vision and the central area would remain hyperopic, losing the purpose of the multifocality (see Figs. 51.10, 51.11, and 51.12).

On the contrary, in the prolate cornea, as in apical keratoconus and post-hyperopic refractive

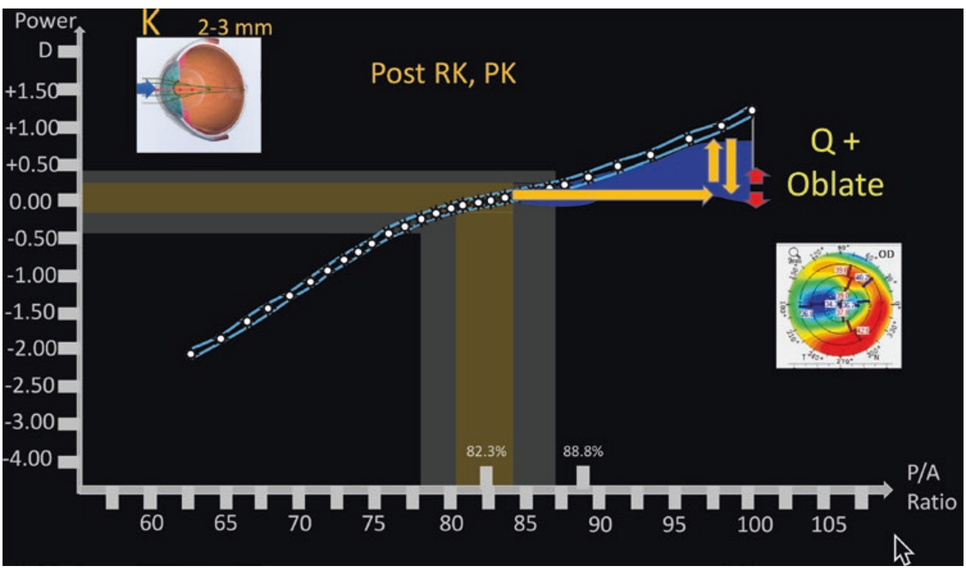

Fig. 51.9 Graph Gullstrand ratio, posterior/anterior ratio vs. gain-loss corneal power in patients with radial keratotomies and keratoplasty

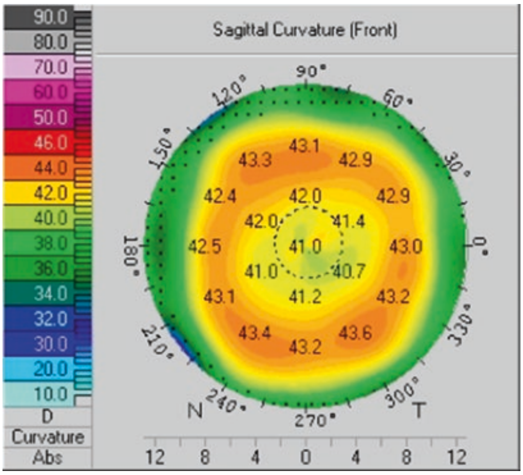

Fig. 51.10 Topographic image of the anterior surface, making corneal oblate asphericity evident, with a lower corneal apical power, in comparison with the higher power in the mid periphery

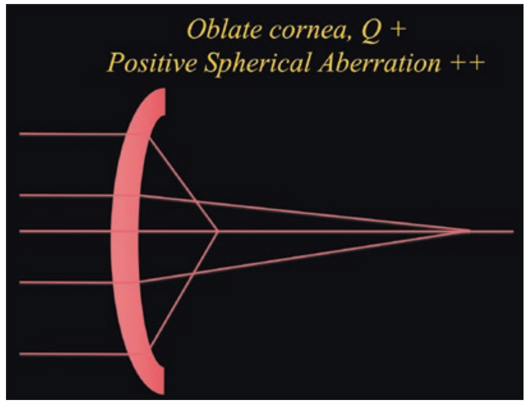

Fig. 51.11 Diagram for positive spherical aberration, the peripheral rays are focused in a point in front of the paraxial rays

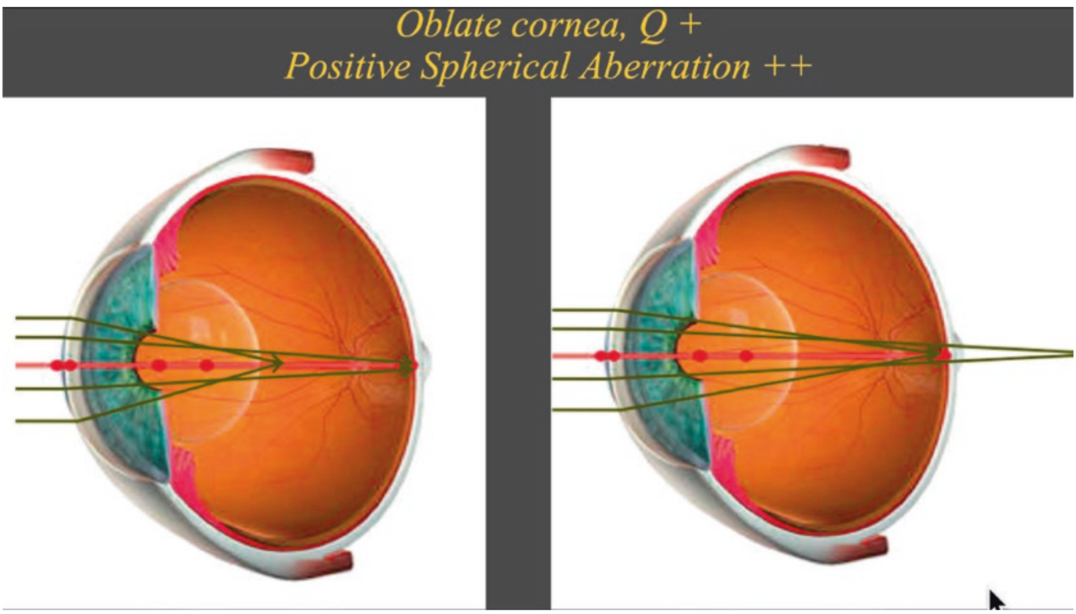

Fig. 51.12 Diagram for the change in spherical aberration in an oblate cornea, by central apical flattening (e.g., Post-Myopic refractive), producing a multifocality, where the paracentral rays are focused on a more posterior point, and the mid peripheral, in a more anterior point

cases, if you wish to use the multifocality, the corneal zones which should be measured are the mid peripheral at 2–4 mm, for far vision, in order to leave the apical K's, which are steeper for near-close vision and thus maintain multifocality, specially under photopic conditions, with miosis, where the rays will go through more apical areas. In these cases, if apical keratometries are used for the lens calculation, the center will lean towards emmetropia, but the mid peripheral cornea to hyperopia and the multifocality idea will be lost (see Figs. 51.13 and 51.14).

In conclusion, if we are to reduce the standard deviation of our results and obtain a greater number of patients close to the expected refractive outcome, we must consider the real corneal power, including the three variables discussed in our calculation programs: **the corneal P/A ratio, the corneal asphericity and its effect in multifocality** (see Fig. 51.15). This will allow us to improve the results not only in normal corneas, where we understand that the standard deviation of these variables exist and may be significant in some patients, but specially in cases of abnormal pathological corneas such as keratoconus and corneal rings segments, or in corneas altered by surgical procedures such as laser refractive surgery, radial keratotomy or penetrating or lamellar keratoplasties.

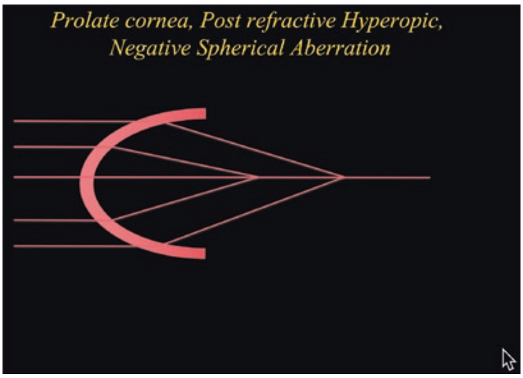

Fig. 51.13 Diagram of the negative spherical aberration, the peripheral rays focused in a point posterior to the paraxials

From the measured keratometry value captured by the Lenstar or IOL Master 700, in optic zones between 1.6 and 2.8 mm, the Panacea program compensates the total corneal power as a function of the relation between the radius of the corneal curvature, at the posterior and the anterior corneal surfaces (P/A), taking into account the Q corneal asphericity of the anterior corneal surface, and the effect on the rest of the more central cornea, in those cases where a more apical measure is needed in order to take advantage of the multifocality (see Fig. 51.16).

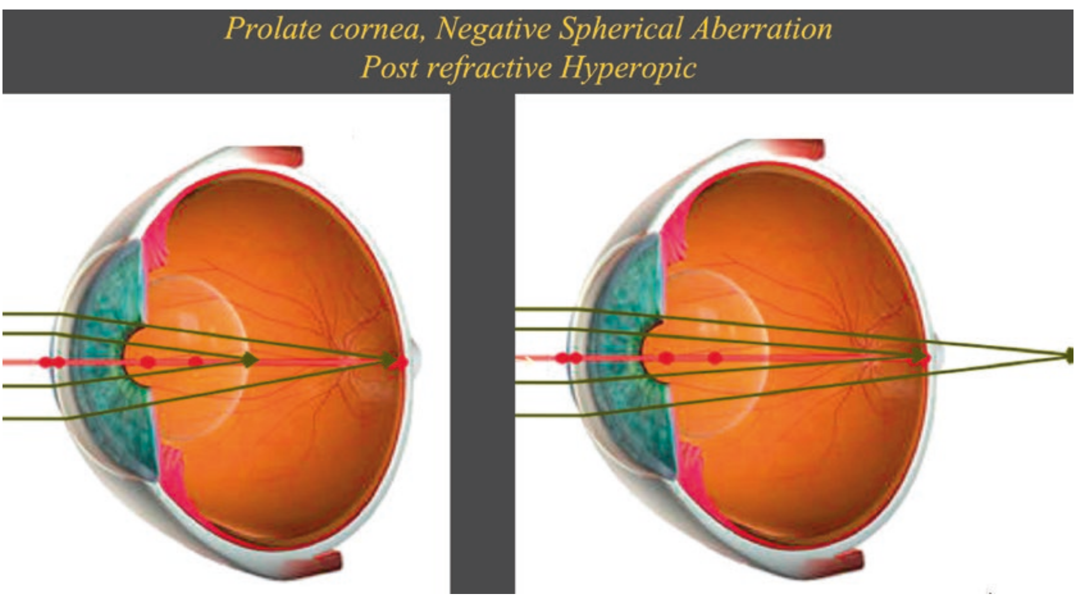

Fig. 51.14 Diagram Spherical aberration in a cornea with high prolaticity, by central apical Steepening (e.g., Post hyperopic refractive), producing a multifocality, where the apical rays are focused in a more anterior point and those at the mid periphery, in a more posterior point

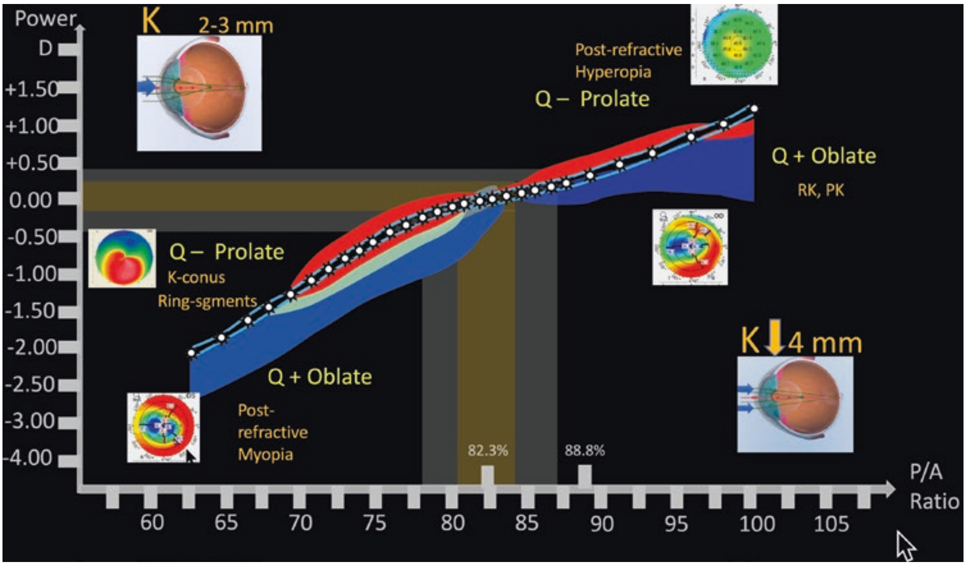

Fig. 51.15 Graph with the relation of the posterior/anterior radius, corneal potency gains or loss in diopters, according to the type of cornea and multifocality

Fig. 51.16 Panacea software images calculating the potency of the IOL according to the P/A ratio in a post-op patient with refractive surgery. 3a: In the first image, the calculations were made assuming the normal PA ratio, as required by any calculator (including the fourth generation formulas). The IOL power calculated is used to provide the patient with emmetrope. 3b: In the second image, the calculation is based on the Real P/A ratio, with a lower P/A, which means that the necessary IOL power is higher, preventing a hyperopic surprise of 2.42 D

The Rocha-de-Lossada and cols. study [45], showed promising results with a better medium absolute error (MedAE 0.178 D) in median axial length, when compared with other 11 formulas, and the results in the groups for ±0.25 D (60.66%) and ±0.75 D (95.08%) (see Table 51.2).

Table 51.2 Comparison of outcomes comparing 12 formulas, in median axial length eyes, axial lengths >22.5 mm and <25 mm (23.44 ± 0.56) (n = 122) [45]

Formula	Refractive prediction error						
	Opt. ME ± SD (D)	MAE ± SD (D)	Med AE (D)	±0.25 D (%)[a]	±0.50 D (%)[a]	±0.75 D (%)[a]	±1.00 D (%)[a]
Barrett	0.00 ± 0.330	0.263 ± 0.197	0.237	54.92	89.34	98.36	100.00
Pearl	−0.01 ± 0.339	0.263 ± 0.214	0.210	57.38	86.89	95.90	100.00
Holladay	0.00 ± 0.352	0.275 ± 0.219	0.219	54.10	86.89	96.72	98.36
EVO	0.00 ± 0.350	0.271 ± 0.219	0.203	60.66	86.07	95.90	100.00
Hill RBF	0.00 ± 0.354	0.276 ± 0.221	0.240	56.56	86.07	97.54	98.36
Panacea	0.00 ± 0.355	0.266 ± 0.234	0.178	60.66	84.43	95.08	99.18
Olsen	0.00 ± 0.365	0.287 ± 0.224	0.225	55.74	84.43	95.08	99.18
Kane	0.00 ± 0.363	0.280 ± 0.230	0.238	53.28	84.43	95.08	100.00
Haigis	0.00 ± 0.379	0.292 ± 0.240	0.225	56.56	82.79	95.90	98.36
SRK/T	0.00 ± 0.373	0.287 ± 0.237	0.240	53.28	82.79	95.90	98.36
Hoffer Q	0.00 ± 0.359	0.284 ± 0.218	0.233	57.38	81.97	96.72	99.18
Ladas	0.00 ± 0.401	0.313 ± 0.250	0.266	48.36	81.15	92.62	99.18

Opt. ME optimized mean error; *SD* standard deviation; *MAE* mean absolute error; *Med AE* median absolute error; *RBF* radial basis function

[a] Eyes with predictive error between ±0.25D, ±0.50D. ±0.75D and ±1.00D

Availability

Panacea IOL & Toric Calculator may be obtained in an open and free manner, for the following platforms:

Web Panacea: www.panaceaiolandtoriccalculator.com

Mac IPAD: https://apps.apple.com/app/id975426922?ign-mpt=uo%3D4

MacDesktop: https://itunes.apple.com/cr/app/panaceaioltoriccalcd/id1107308495?l=en&mt=12

PC Desktop: www.panaceaioltoriccalc.com

Conclusion

A modern formula must have every available tool in order to increase its good results, including improvements in biometry, such as correction factors in the axial length and its segments, as well as in the real retinal thickness, the estimation of the effective lens position, with the inclusion of new variables if needed, such as the P/A ratio in the optimization of the corneal curvature value used in the estimation of the ELPo.

The total corneal power, and the P/A ratio in particular, are not only important for those "naive" normal corneas, whose standard deviation may induce a significant error in some cases, but it is also of particular importance, in eyes with abnormal corneas, affected after refractive surgeries, lamellar or penetrating keratoplasties, and corneal ectasias.

A formula which considers the relation of both corneal curvatures, the corneal asphericity and the multifocality, can perform the calculations with the objective data taken from a tomograph and a biometer, avoiding the need of formulas that depend on the eye or cornea characteristics.

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