Online IOL Power Calculators

57

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Online Calculators for Spherical and Toric IOL Power

ASCRS Post-refractive IOL Calculator

The American Society of Cataract and Refractive Surgery (ASCRS), 15 years ago, developed a free online IOL calculator (https://ascrs.org/tools/post-refractive-iol-calculator) for eyes with previous corneal refractive surgery. The calculator has undergone continuous modifications over time and has three sections.

- **Prior Myopic LASIK/PRK:** Required inputs are axial length (AL), flattest keratometry (K1), steepest keratometry (K2), target refraction (Rx), and the A-constant of a given IOL. If no other parameters are entered, the results of two no-history formulas are shown: the Barrett True-K (see below) and Shammas-PL. Entering anterior chamber depth (ACD, from corneal epithelium to lens) enables the calculation of the Haigis-L formula also. If other parameters are entered (e.g., refractive change induced by the laser), a total of seven formulas with historical data and seven no-history formulas are shown.
- **Prior Hyperopic LASIK/PRK:** Required inputs are the same for myopic LASIK/PRK. A total of four no-history formulas and five formulas with historical data are computed.
- **Prior Radial Keratotomy (RK):** Using the same above mentioned parameters, seven formulas are displayed.

Barrett Formula Website (Fig. 57.1)

The formulas developed by Graham D. Barrett MD are available on the website of the Asia-Pacific Association of Cataract and Refractive Surgery (www.apacrs.org). Under the heading "IOL formulae," it is possible to perform several calculations:

- **For Unoperated Eyes:** The Barrett Universal II formula is available. A dropdown menu enables surgeons to select one of 18 IOL models, each with its own lens factor. Alternatively, if another IOL has to be used, its A-constant is

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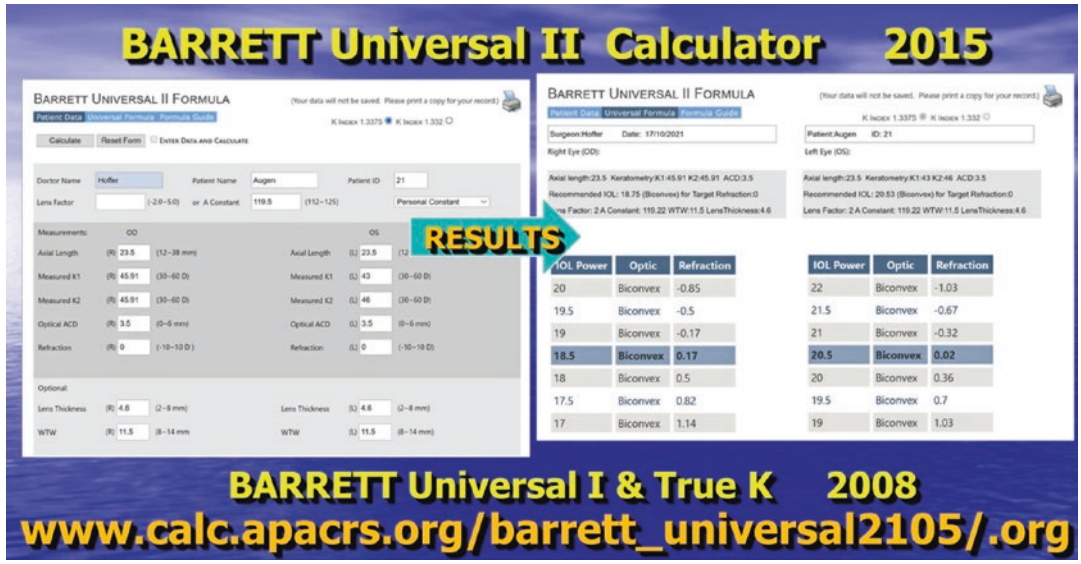

Fig. 57.1 Barrett online calculator

entered and automatically converted into the lens factor. Mandatory entries include AL, K1, K2, and target Rx. The IOL power can also be calculated without entering the ACD, but it is recommended to use this parameter. Optional values are the lens thickness (LT) and horizontal corneal diameter (CD).

- **For Unoperated Eyes Requiring a Toric IOL:** The Barrett Toric calculator is available. The dropdown menu includes 25 IOL models, each with its own lens factor. The A-constant can also be entered for other IOL models. In addition to AL, K1, K2, ACD, and target Rx, the flat axis and steep axis are required. The surgically induced astigmatism (SIA) and the incision location are optional, as well as LT and CD. This calculator offers two interesting opportunities: (1) the possibility to enter the measured posterior corneal astigmatism (PCA), obtained by five different instruments, and (2) the possibility to enter the K1 and K2 of three different devices, whose measurements are averaged. Both options are intended to improve the refractive accuracy. In any case, the keratometric astigmatism (KA) entered by the surgeon is optimized according to an unpublished method, such that it decreases in eyes with with-the-rule (WTR) astigmatism and increases in eyes with against-the-rule (ATR) astigmatism in order to take the PCA into account. The Barrett toric calculator not only calculates the toric power of the IOL, but also calculates the spherical equivalent (SE) power.
- **For Eyes with Previous Corneal Refractive Surgery and Keratoconus:** (Myopic or Hyperopic LASIK and RK) and for eyes with Keratoconus: The Barrett True-K formula is available and the dropdown menu includes 26 IOL models, each with its own lens factor. The A-constant can be entered for other IOL models. In addition to the parameters needed for the Barrett Universal II formula, users may enter the refractive change induced by LASIK and the measured PCA (either from the IOLMaster 700 or the Pentacam). These parameters have been shown to improve the prediction accuracy in eyes with previous corneal refractive surgery.
- **For Toric IOL Powers in Eyes with Previous Excimer Laser Surgery or RK:** The Barrett True-K toric calculator merges the capabilities of the True-K formula and the standard toric

calculator to calculate, but contrary to the True-K formula, it does not offer the keratoconus option.

- **For Special Situations:** The Barrett Rx formula has been developed to calculate the IOL power in situations where a refractive error has occurred after cataract surgery. It enables surgeons to calculate the IOL power of piggyback IOLs or the IOL power when an IOL exchange is preferred. The "patient data" display must be populated with specific values, such as the power of the implanted IOL (SE and, if needed, cylinder) and the postoperative (PO) refraction (sphere, cylinder, and axis). In addition to the PreOp K1 and K2 (with their axes), the PO corresponding values are required. Of course, AL, ACD, and target refraction are mandatory. SIA, LT, and CD are optional. The dropdown menu includes 18 IOL models with their own lens factor. For other IOLs, the A-constant must be entered. With both exchange IOL and piggyback IOL modules, the Rx formula suggests also the best meridian along which the toric IOL should be aligned and predicts the residual astigmatism.

Cooke K6 Formula Website (Fig. 57.2)

The website to access the K6 formula, developed by David L. Cooke, MD, is https://cookeformula.com. This is a thin-lens formula where the effective lens position (ELP) is computed with thick-lens calculations and the AL is internally modified to simulate the sum-of-segment axial length (CMAL, Cooke-modified axial length). The user is provided with the opportunity to select the Argos (Alcon) AL, which eliminates the need for internal AL modification, and can select one out of 5 keratometric indices and 20 IOL models, each with its own A-constant. Required variables are AL (there is an Argos option), central corneal thickness (CCT), ACD, LT, CD, K1 and K2, and target Rx, and these parameters are mandatory for the formula to run.

EVO Formula Website (Fig. 57.3)

The Emmetropia Verifying Optical (EVO) formulas developed by Tun Kuan Yeo, MD, are available at https://www.evoiolcalculator.com/start.aspx. The website includes three calculators.

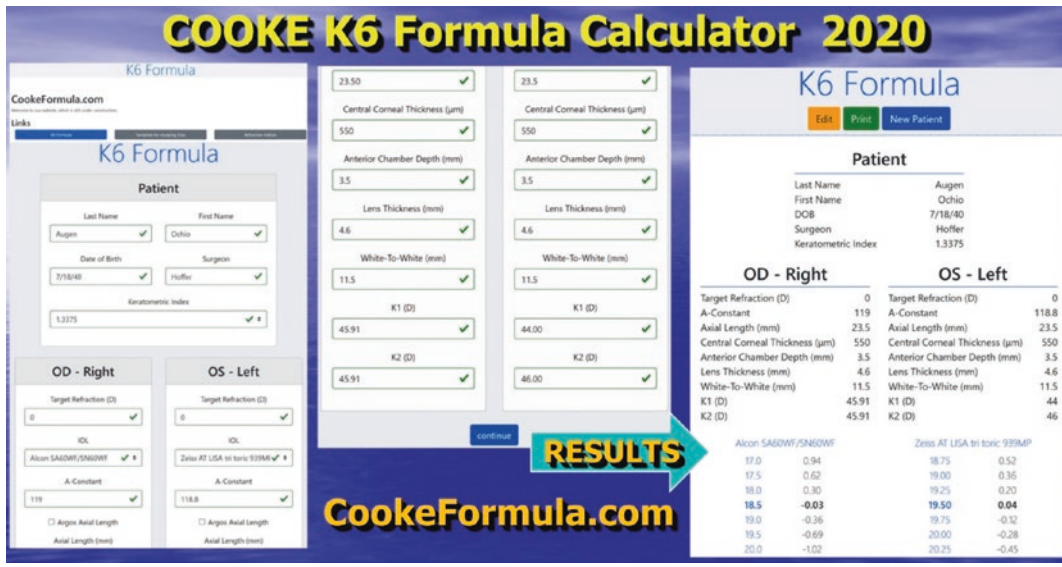

Fig. 57.2 Cooke K6 online calculator

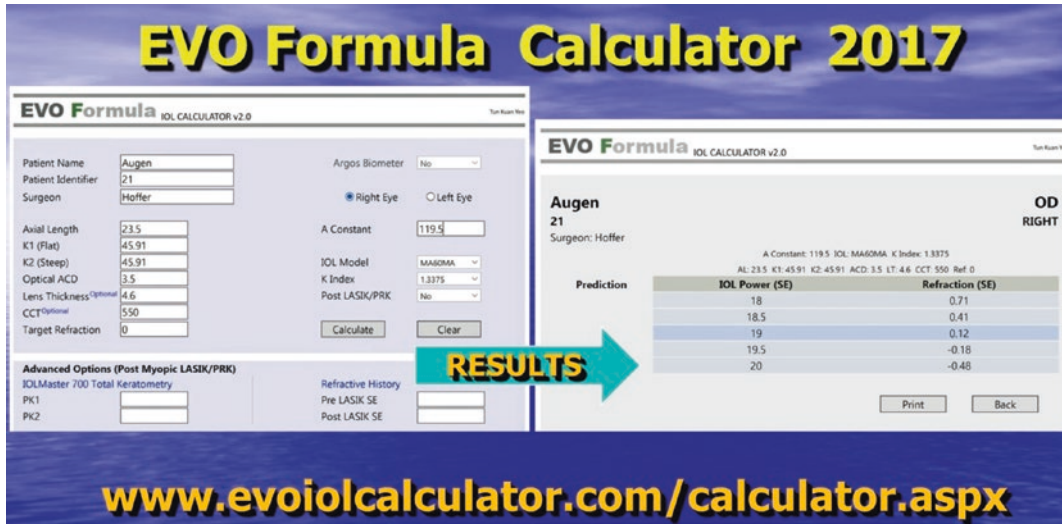

Fig. 57.3 EVO online calculator

- **The EVO (Version 2.0)** (https://www.evoiolcalculator.com/calculator.aspx) is a thick-lens formula and requires five mandatory variables: AL, ACD, K1, K2, and target Rx. LT and CCT are optional. A dropdown menu includes three IOL models. For all other IOL models, it is recommended to enter the www.iolcon.org lens constants. The user has to specify whether the Argos biometer was used or not, as it calculates the AL with the sum-of-segments, which leads to different values in eyes longer than 25 mm. If the Argos has been used, the EVO compensates for the change in AL with respect to traditional optical biometers.
- **The EVO Toric Calculator** (https://www.evoiolcalculator.com/toric.aspx) calculates the cylinder of toric IOLs once the AL, ACD, K1, K2 (with their axes), and target Rx are provided. SIA, LT, and CCT are optional. The dropdown menu offers the choice among four IOL models; for other IOLs, the surgeon has to select whether the toricity is manufactured on the anterior surface of the IOL, on the posterior surface, or both. The results of the toric calculator show the SE power of the IOL, its cylinder, the recommended axis of alignment, and the predicted Rx (sphere, cylinder, and axis).
- **The Post-LASIK EVO Formula Calculator** was developed for eyes that underwent myopic refractive surgery. It can work as a full no-history formula, but it offers the user the opportunity to enter the preoperative (PreOp) and the PO refraction and the posterior corneal curvature (PK1 and PK2) measured by the IOLMaster 700. The post-LASIK option can be selected from both the EVO formula and the EVO toric calculator.

Hoffer QST Formula Website (Fig. 57.4)

The Hoffer QST (Q/Savini/Taroni) is the evolution of the Hoffer Q formula, which has been used for 30 years by ophthalmologists around the world. It can be accessed at https://HofferQST.com and www.EyeLab.com. The calculator offers three options.

- **For Unoperated Eyes:** The improvements of the Hoffer QST over the original Hoffer Q regard the ELP, which is predicted using artificial intelligence (with the average of K1 and K2, anterior corneal radius, Pre-Op ACD, AL, and gender) as inputs of a machine learning algorithm as well as the AL, which is opti-

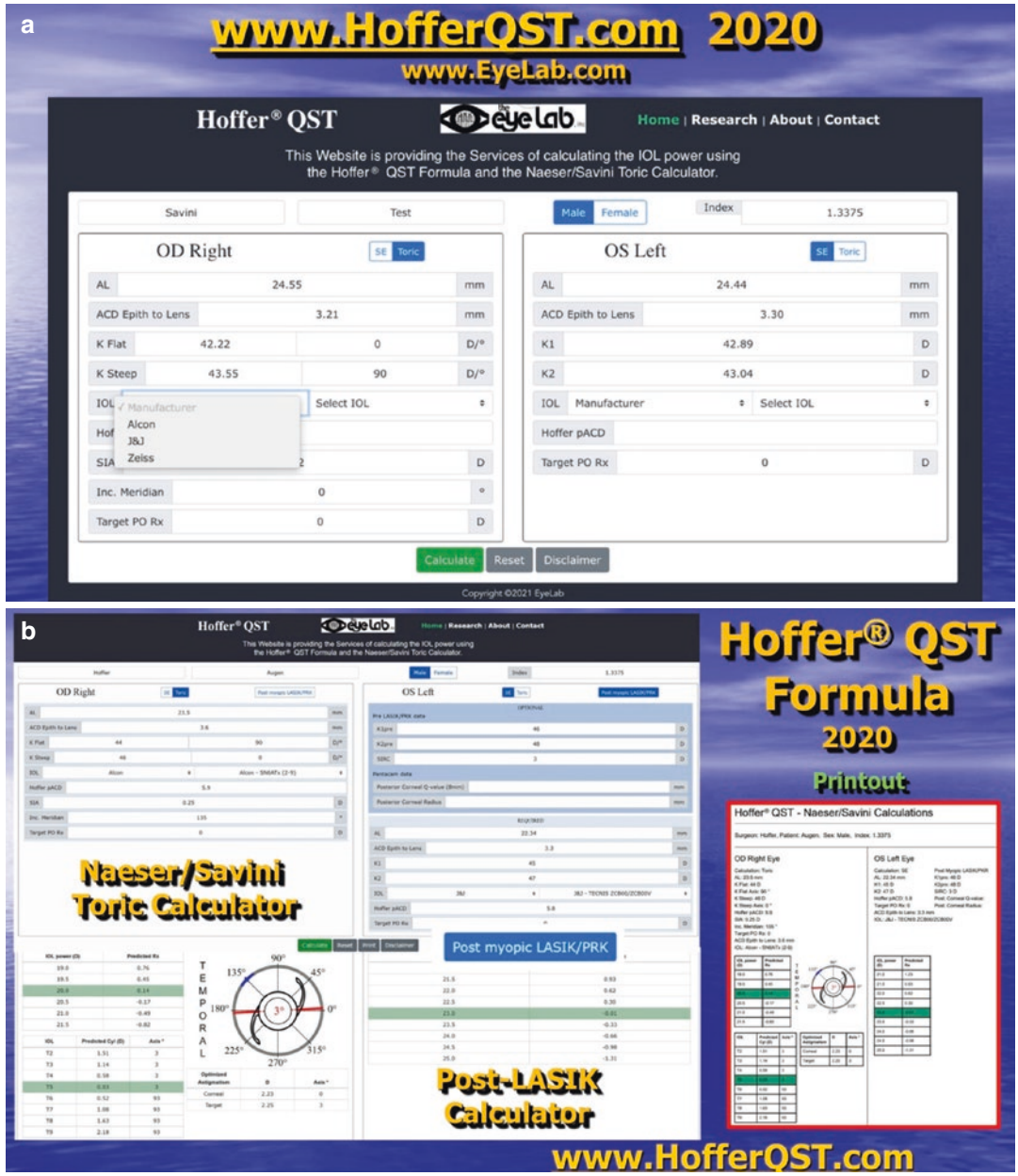

Fig. 57.4 (**a**) Hoffer QST online calculator: standard calculation page. (**b**) Hoffer QST online calculator: toric and post-LASIK calculation page with a printout. (**c**) Hoffer QST online calculator: constant personalization and research

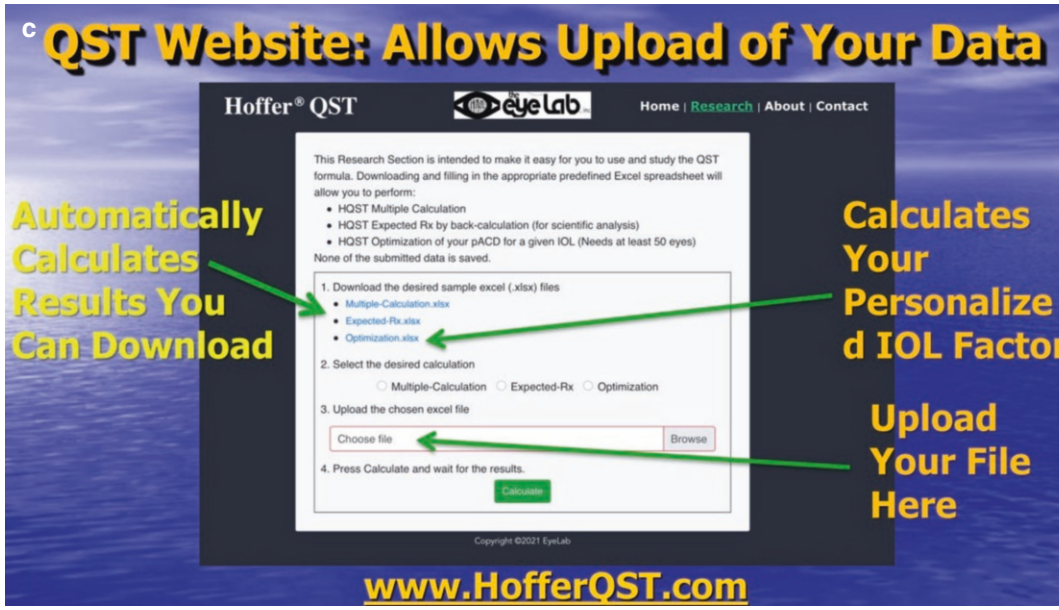

Fig. 57.4 (continued)

mized for long eyes again by means of a machine learning algorithm. The formula was developed in order to maintain the IOLCon pACD constants of the Hoffer Q formula. Required data are AL, ACD, K1, K2, gender, and target Rx. The dropdown menu includes **61 IOL models** from 10 manufacturers.

- **For Toric IOLs:** The Næser/Savini toric calculator is applied to the Hoffer QST formula. In this case, the axes of K1 and K2 and SIA are required. The results are based on the keratometric astigmatism optimization, which reduces the amount of cylinder in eyes with WTR astigmatism and increases it in eyes with ATR astigmatism. The results include the SE power, the cylinder power, and orientation of the IOL, as well as the optimized astigmatism and the predicted refraction.
- **For Post-LASIK Eyes:** This can work as a full no-history method, where AL, ACD, K1 and K2, gender, and target Rx are the only required data. In addition, the refractive change induced by LASIK can be entered. In order to improve the double-K method used to predict the ELP, the posterior corneal radii or, if Pentacam measurements are available, the posterior corneal curvature and asphericity (Q-value) can be entered.
- **For Research and Constant Optimization:** Uniquely, a research section is available (https://HofferQST.com/research). This was included to help clinicians calculate their personalized lens factor and more importantly for researchers to investigate the outcomes of the Hoffer QST formula in their datasets when comparing the results of various formulas. Five Excel files can be downloaded: (1) a multiple calculation file to calculate the IOL power in large datasets; (2) an expected refraction file to calculate the expected Rx; (3) a multiple calculation file for post-LASIK eyes; (4) an expected refraction for post-LASIK eyes; and (5) an optimization file, which calculates the optimized Hoffer pACD for each dataset. Once these files are filled out with all the data from PO eyes, they can be uploaded and the results are provided to the surgeon anonymously.

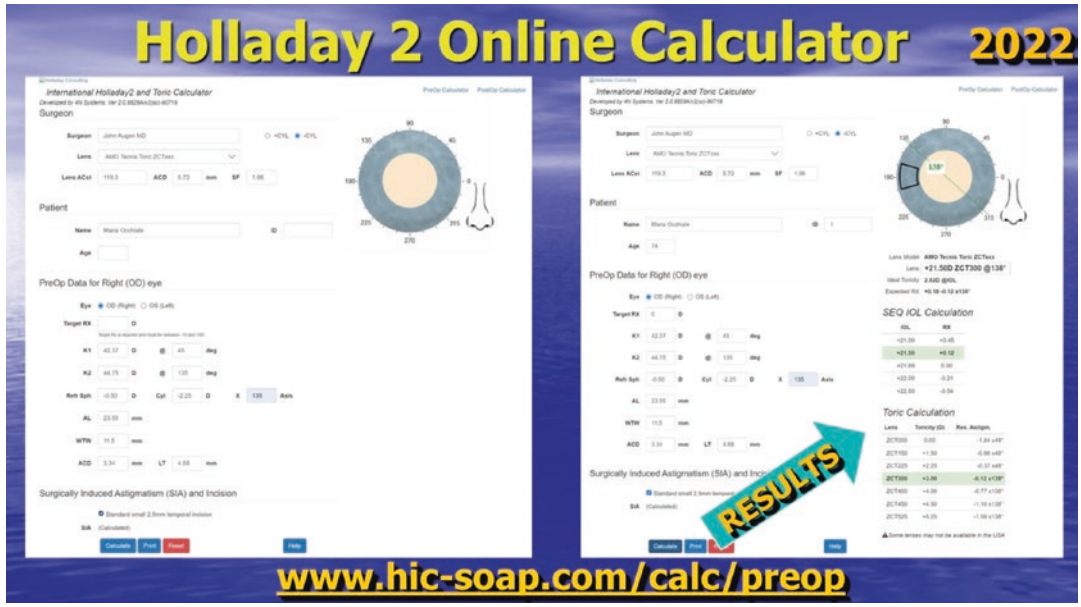

Fig. 57.5 Holladay 2 online calculator

Holladay 2 Formula (Fig. 57.5)

The Holladay 2 and toric calculator can be accessed at https://www.hic-soap.com. The SE power of the IOL is calculated with the Holladay 2 formula and the cylinder with Holladay's toric calculator. Several PreOp variables are necessary: AL, ACD K1 and K2 with their axes, CD, target Rx, and the PreOp Rx. A standard SIA is used, unless the user enters a personalized value. The dropdown menu offers 17 IOL models with their lens constants.

Also, a PO calculator is included to help surgeons rotate the toric IOL if the PO Rx is far from the target. The ideal alignment is calculated from the PO Ks and Rx of the observed IOL alignment and PO Rx.

Kane Formula Website (Fig. 57.6)

The results from the Kane formula, developed by Jack X Kane, MD, can be accessed at https://www.iolformula.com.

- **For Unoperated Eyes:** The Kane formula requires AL, ACD, K1, K2, gender, and target Rx, while LT and CCT are optional. 14 IOL models are available in the dropdown menu. If another IOL has to be used, its A-constant has to be manually entered. The formula has been developed to have an A-constant similar to the SRK/T A-constant. If the surgeon has an optimized A-constant, then that is recommended for use. Otherwise, the IOLCon SRK/T A-constant for any particular IOL should be used.
- **For Unoperated Eyes with Corneal Astigmatism:** The Kane toric calculator requires the axes of K1 and K2 and SIA to perform the calculation (it is recommended to use an SIA of zero with the Kane toric formula when performing surgery with a temporal incision size of ≤2.75 mm). As with other newer generation toric calculators, the keratometric astigmatism is adjusted to take PCA into account. The SE power and cylinder of the toric IOL are provided, as well as the suggested orientation and the predicted refraction.
- **For Unoperated Eyes with Keratoconus:** The Kane formula is specifically adapted. The surgeon must select the "Keratoconus" option, and the same variables as for the standard for-

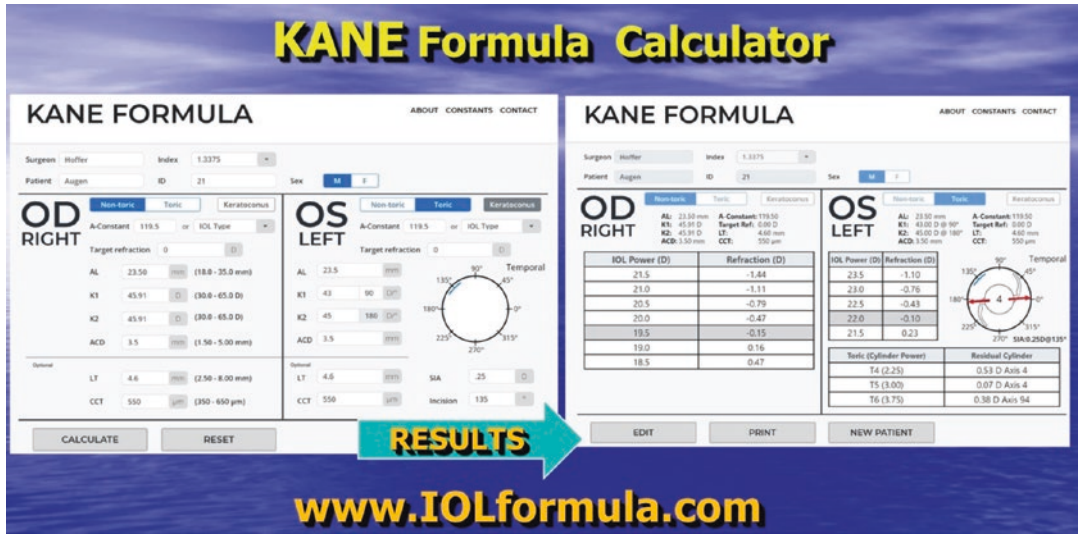

Fig. 57.6 Kane formula online calculator

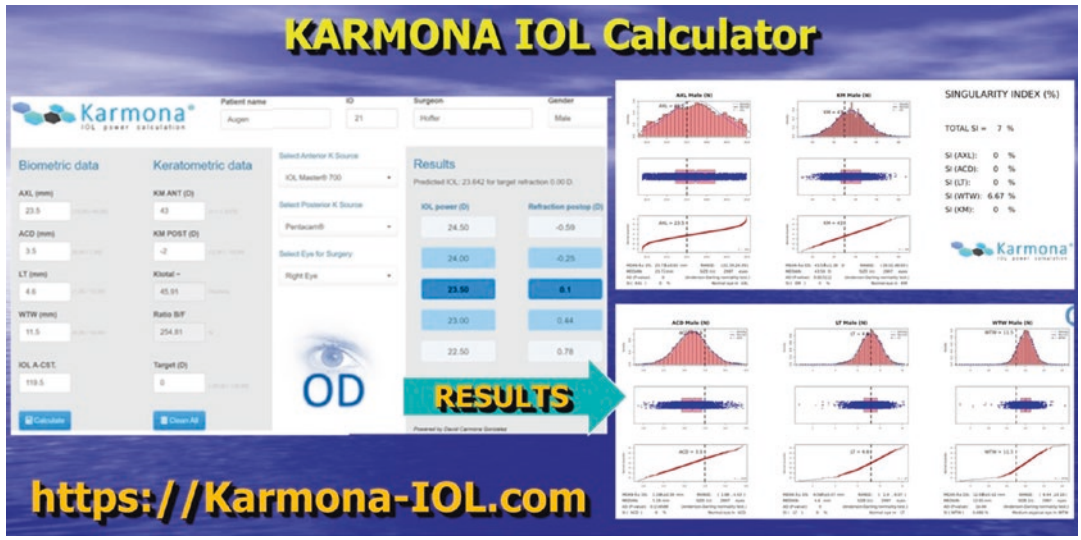

Fig. 57.7 Karmona online calculator

mula are required. The Kane formula for keratoconus is based on a modified corneal power, derived from the anterior corneal radii of curvature. The formula also reduces the impact of corneal power on the ELP calculation. A myopic target refraction is recommended in patients with an average corneal power > 48 D. Between 48 D and 53 D, a target of −0.50 diopter (D) is recommended; between 53 D and 59 D, a target of −1.00 D is recommended; and above 59 D, a target of −1.50 to −2.50 D is recommended.

Karmona Formula Website (Fig. 57.7)

This is another calculation method based on artificial intelligence, available at https://karmona-iol.com and developed by David Carmona Gonzales, PhD. Required variables are AL, ACD,

$K_{average}$, CD, and target Rx. LT and posterior K are optional. Standard A-constants have to be entered in order to calculate the IOL power and the expected Rx. Interestingly, a Singularity Index is provided for each eye, with the purpose of alerting the surgeon of unusual combinations of PreOp biometric parameters. The Singularity webpage also features multiple graphs showing the distribution of each parameter compared to the general population. The "Researchers" webpage contains an Excel file that can be downloaded, populated with the biometric data of any surgeon, and uploaded to achieve the results of the Karmona formula for multiple eyes.

Ladas Formula Calculator (Fig. 57.8)

The outcomes of this formula can be obtained at https://www.iolcalc.com. It represents the evolution, based on artificial intelligence and big data methodology, of the original Ladas super formula, which used the best portions of the Haigis, Hoffer Q, Holladay 1, and SRK/T formulas based on AL ranges originally recommended and published by Hoffer [1] in 1993. For unoperated eyes, AL, K1 and K2, and target Rx are sufficient to calculate the SE power of the IOL, whereas PreOp ACD can be entered as an optional input. There are no IOLs to be selected, and the user has to individually enter the A-constant value (default values can be entered in the "Preferences").

The website requires registering with personal information and being approved by them before the calculator can be used. Their toric calculator and a post-LASIK calculator are in development and not yet available.

Nallasamy Formula Website (Fig. 57.9)

This is a method entirely based on artificial intelligence (more specifically, ensemble learning). Calculations can be obtained at https://lenscalc.com. Required data input are AL, ACD, K1, K2, CD, LT, age, and target Rx. CCT is an option. Calculations are available only for one IOL model (AcrySof SN60WF, Alcon).

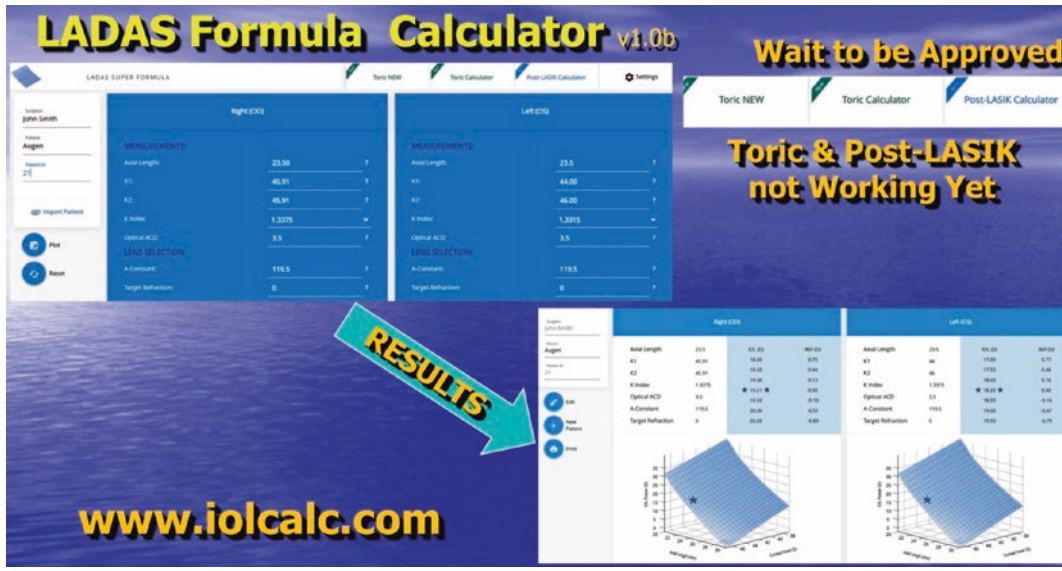

Fig. 57.8 Ladas online calculator

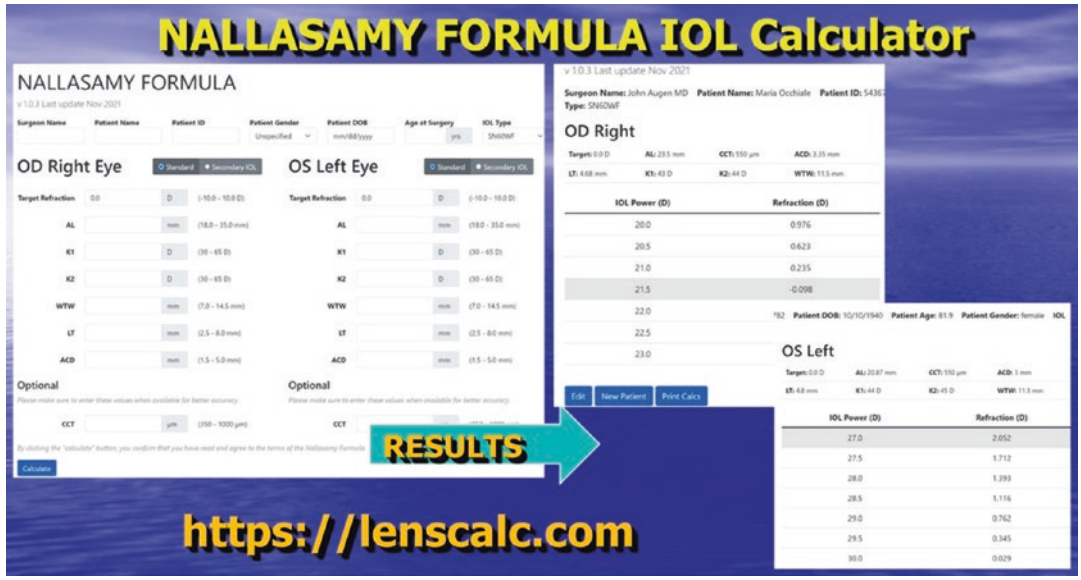

Fig. 57.9 Nallasamy online calculator

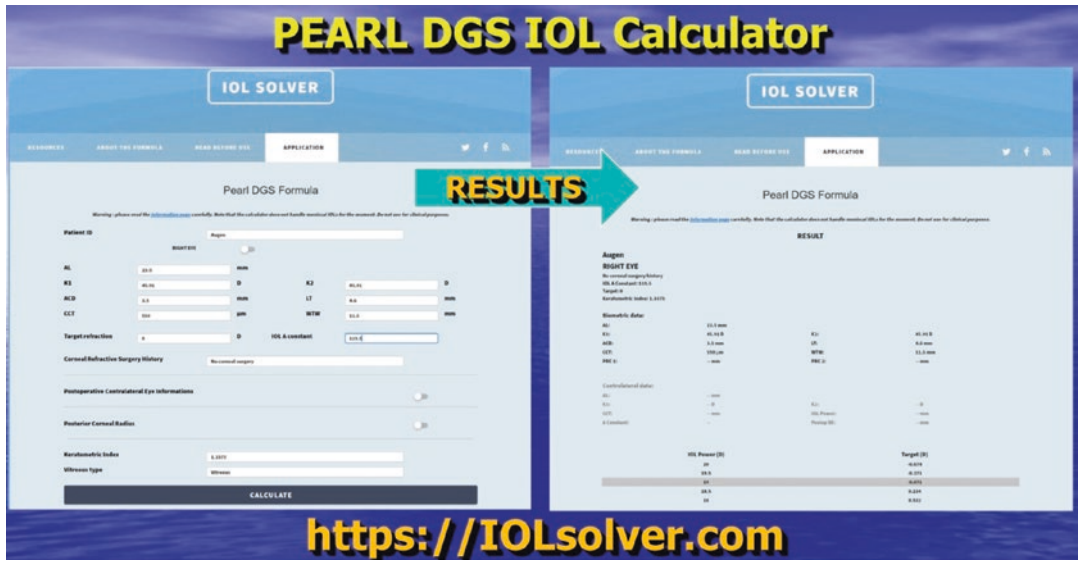

Fig. 57.10 Pearl DGS online calculator

PEARL DGS Formula Website (Fig. 57.10)

Developed by Guillaime Debellemaniere MD, Damien Gatinel MD PhD, Alain Saad MD, the PEARL (PO SE Prediction using ARtificial Intelligence and Linear algorithms), the DGS formula is available at **https://iolsolver.com/main**. This is a thick-lens formula considering every radius, thickness, and refractive index. Prediction of the IOL distance from the cornea is based on artificial intelligence. AL is modified according to Cooke (CMAL) to approximate the sum-of-segment AL.

- **For Unoperated Eyes**, AL, ACD, K1, K2, CCT, LT, CD, and target Rx are all mandatory entries. The posterior corneal radii can be entered if measured by any instrument; otherwise, they are predicted from the anterior corneal curvature. The A-constant has to be manually entered. Interestingly, this is the only formula allowing the use of the contralateral eye information if it has had IOL surgery: The user can enter AL, K1, K2, CCT, power of the implanted IOL, and PO Rx to improve the prediction of the IOL power in the second eye.
- **For Eyes with Previous Myopic or Hyperopic Excimer Laser Surgery:** A version of their formula has been developed for these and eyes with previous RK.

RBF 3.0 Calculator Website (Fig. 57.11)

This method, which is available at https://rbfcalculator.com/online/index.html, employs Radial Basis Function, a form of artificial intelligence based on pattern recognition, and has been developed for unoperated eyes. It has been optimized for use with biometry data from the Haag-Streit Lenstar LS 900 optical biometer in combination with the Alcon SN60WF biconvex IOL for powers from +6.00 D to +30.00 D and IOL powers up to +35.00 D based on a similar biconvex IOL design. For IOL powers from +5.00 D to −5.00 D, it performs best with this combination of biometry devices and the Alcon MA60MA extended range IOL. The RBF calculator may also be used with data from other optical biometers, which provide clinically equivalent biometry data as compared to the Lenstar LS 900 (which is almost all of them except the Argos unit). It may also be used with other biconvex IOL models in the power range of +6.00 D to +35.00 D and other meniscus design IOL models in the power range of +5.00 D to −5.00 D.

Required inputs depend on the optical biometer used. For older instruments, the IOLMaster 500, AL, ACD, K1 and K2, gender, and target Rx are sufficient. For newer instruments, additional optional inputs are LT, CCT, and CD. The "lens constants" section provides users with a list of IOL models and their A-constant to be adopted.

About 1.5% of eyes will be classified as "out of bounds," i.e., cases whose refractive prediction may be less accurate than usual.

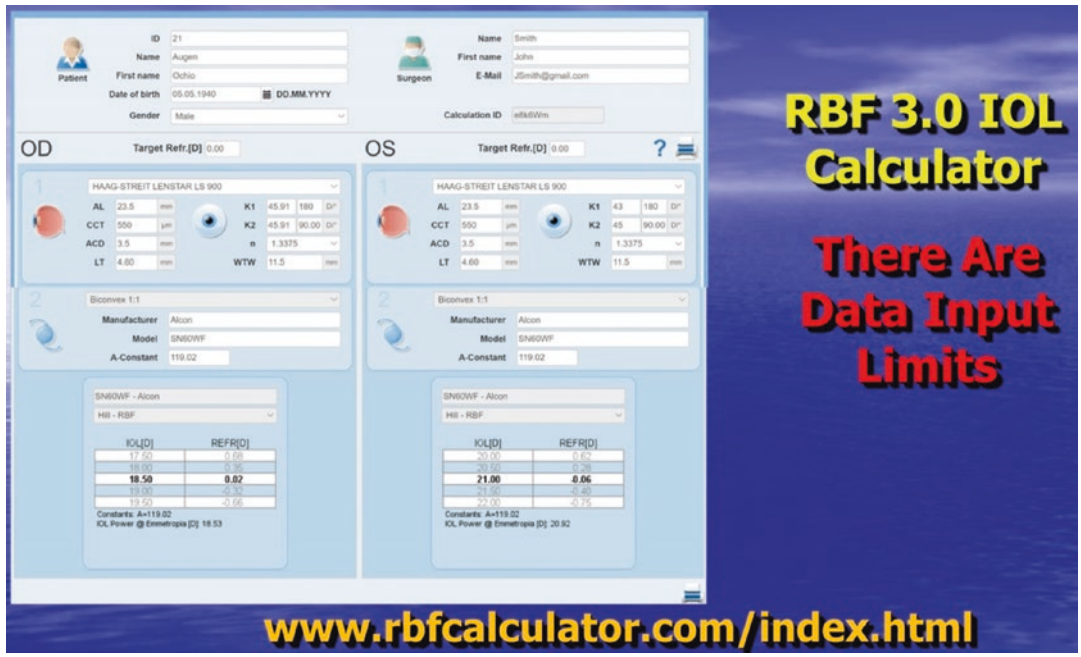

Fig. 57.11 RBF 3.0 online calculator

Fig. 57.12 Online website calculator printouts

PRINTOUTS

All formula websites provide a printout for the chart (Fig. 57.12). We are gratified to see that many formulas and websites have added the additional factor of gender which we first pointed out as an important determinant for IOL power in 2017 [2].

ESCRS all Formula Calculator (Fig. 57.13)

The newest and easiest way to use an online calculator was first conceived by Dante Buonsanti MD of Buenos Aires, Argentina and has been sponsored and developed by the European Society of Cataract and Refractive Surgery (ESCRS).

Fig. 57.13 (**a**) ESCRS all formula online calculator: data entry. (**b**) ESCRS all formula online calculator: results when all seven formulas chosen

This calculator (https://iolcalculator.escrs.org/) facilitates the routine effort of ophthalmologists who want to use the latest IOL power formulas for their patients which are not available on their biometer. Users select any or all the formulas they want results for. All they have to do is enter AL, K1, K2, ACD, LT, CCT, CD, gender, and target Rx only one time, and with one click, the results of as many as seven formulas are simultaneously calculated through each formula website: Barrett Universal II, Cooke K6, EVO 2.0, Hoffer QST, Kane, Pearl DGS, and RBF 3.0. This is performed by a Web scraping technology with the permission of all the formula authors. The ESCRS IOL

calculator provides recommended lens constants for various IOL models. If a formula specifies a constant for an IOL, the value is obtained from the formula's site. If not, the suggested constants from the IOLCon website are utilized. These constants are optimized if possible, or else those suggested by the manufacturer/ULIB are used. In all cases, an information button is available next to the constant, providing details on where it originated and alternative options. Additionally, users have the option to manually adjust all values. A printout is available that provides the results of all the formulas on one page. There is also the convenient option to use either a comma or a period as a number separator.

Online Calculators for Toric IOL Power

ASSORT Web Calculators

The Alpins Statistical System for Ophthalmic Refractive Surgery Techniques (Assort) has been developed by Noel Alpins MD at www.assort.com. The Web calculators section includes a toric IOL calculator and has two sections: PreOp planning and refractive surprises analysis. The first one requires K1, K2, and steep meridian and provides users with three choices for calculations: standard Ks, Abulafia-Koch adjustment, and total corneal astigmatism (as directly measured by a Scheimpflug camera or an OCT). Once you log in, the calculator is not entirely free, as the use of only four (4) patients is allowed. The spherical power of the IOL is calculated with the Haigis, Hoffer Q, Holladay 1, and SRK/T formula. Formula constants need to be entered by the user.

The refractive surprise analysis can calculate the effect of PO rotation of the toric implant in the case of a refractive surprise.

In addition, a large number of toric calculators have been developed by all manufacturers of toric IOLs (Fig. 57.14). This is a list of the most commonly used:

Alcon: https://www.acrysoftoriccalculator.com

Bausch + Lomb: https://envista.toriccalculator.com

Hanita: https://calc.hanitalenses.com/toric-iol-calculator-v5-01/

Hoya: www.hoyatoric.com

Johnson & Johnson Vision: https://tecnistoric-calc.com

Kowa: https://avanseetoriccalculator.com

Omni: http://www.omnilens.in/portfolio/toric-calculator/

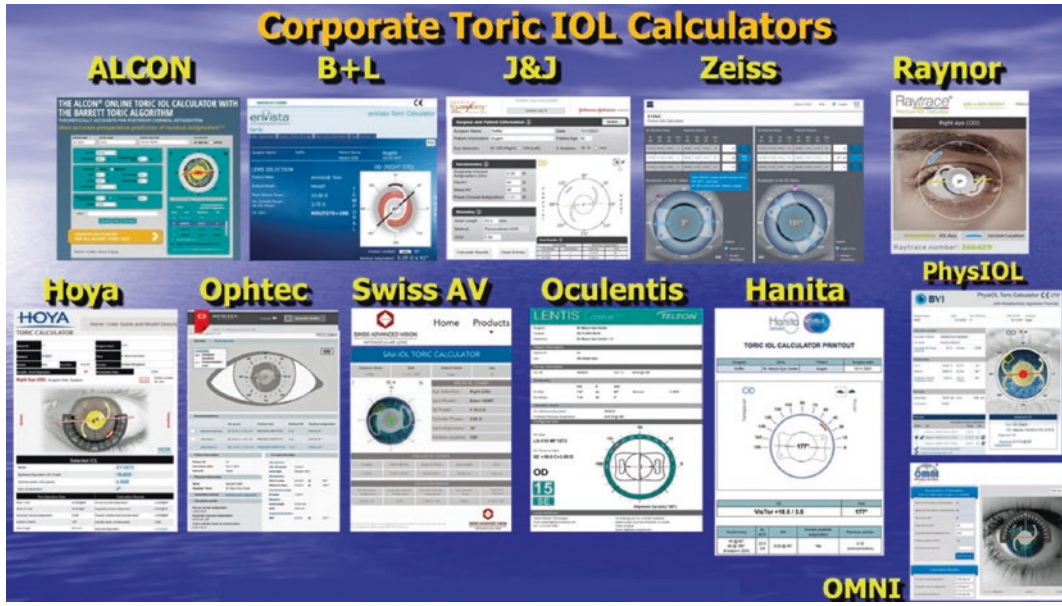

Fig. 57.14 Corporate toric online calculators

Ophtec: https://calculator.ophtec.com/calculator-choice
Physiol: https://www.physioltoric.eu
Rayner: https://www.raytrace.rayner.com
VSY: https://easytoriccalculator.com
Zeiss: https://zcalc.meditec.zeiss.com

Free Downloadable Apps for Spherical and Toric IOL Power

Panacea Formula

This formula, developed by David Flikier MD, of Costa Rica, is not online, but the program can be downloaded at http://www.panaceaiolandtoric-calculator.com/downloads.html. The installed application contains several unique features.

- **The IOL power calculator** is intended for non-toric IOLs to be implanted in unoperated eyes. Required data include AL, ACD, $K_{average}$, and LT. In addition, the ratio of the anterior and posterior corneal radii and the asphericity (Q-value) can be entered to further refine the IOL power calculation. The A-constant of 38 IOL models from five manufacturers is available.
- **The toric calculator** provides the cylinder power of the IOL based on the keratometric astigmatism, calculated from the anterior corneal radii and the flat meridian axis. PCA and SIA can be entered to further improve the predicted outcome.
- **The postop toric calculator** aims to show the ideal toric IOL orientation in eyes that have undergone previous toric IOL implantation but had an unexpected residual astigmatism. After entering the PO Rx (sphere, cylinder, and axis), the AL and K, the cylinder of the implanted IOL, and its PO alignment, the surgeon can visualize the predicted residual astigmatism. By virtually rotating the IOL from 0 to 180°, it is possible to see the predicted astigmatism for each degree of rotation and select the best IOL orientation. Alternatively, a new toric IOL can be calculated if IOL replacement is planned.
- **The aphakic IOL calculator** is based on the following variables: AL, K, subjective refraction (SE) with vertex distance, A-constant, and anterior-to-posterior corneal radii ratio.

Appendix

In addition to the previously described calculators, it is important to remember two landmark websites. First, the ULIB page (http://ocusoft.de/ulib/c1.htm) was developed by Wolfgang Haigis PhD and was available until 2015. This page contains the optimized constants for hundreds of IOL models. The ULIB website was also the first online calculator, as it enabled individual IOL power calculation with the Haigis, Hoffer Q, and SRK/T formulas. Second, the IOLCon website (https://iolcon.org), developed under the guidance of Prof. Dr. Achim Langenbucher, who continued the work of Haigis, is still collecting and optimizing the constants of newer and older IOL models.

Reference

1. Hoffer KJ. The Hoffer Q formula: a comparison of theoretic and regression formulas. J Cataract Refract Surg 1993;19(11):700–12. Errata 1994;20:677 and 2007;33(1):2-3.
2. Hoffer KJ, Savini G. Effect of gender and race on ocular biometry. Int Ophthalmol Clin. 2017;57(3):137–42.