

IOLMaster® 500 and Integration of the Holladay 2 Formula for Intraocular Lens Calculations

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Abstract

The use of advanced formulas to improve the accuracy of cataract surgery has been a process of ongoing improvement since the 1980s. Today's leading formula – Holladay 2 – has now been added directly to the IOLMaster® 500 device (Carl Zeiss Meditec AG). This will allow a much larger group of surgeons to access the latest formula and should improve both intraocular lens calculation and the resulting visual outcome.

Keywords

Intraocular lens calculations, Holladay 2 formula, IOLMaster®

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The IOLMaster®, first launched as a novel approach to obtaining biometric data, has evolved over the past decade to become the predominant device and standard routine used in a surgeon's intraocular lens (IOL) calculations prior to cataract surgery. Previous surveys by SM2 Strategic documented its value as a tool in modern cataract surgery as well as the ongoing improvement of the platform in terms of both speed and ability to read accurately through dense cataracts.^{1,2} Carl Zeiss Meditec Inc. (Dublin, California) recently launched a new innovation that brings the Holladay 2 formula directly into the IOLMaster device, an upgradable feature that is designed to further improve outcomes with added convenience for the surgeon and increased workflow. SM2 Strategic was asked to provide a historical perspective on the evolution of IOL formulas, which was accomplished through a review of the literature and an interview with Jack Holladay, well-known as a surgical innovator, optics expert and developer of today's leading Holladay 2 formula.

History of Intraocular Formulas

The theoretical basis for today's advanced IOL power calculations was first developed over 100 years ago and, for decades, surgeons worked with an assumed anterior chamber depth (ACD) of 4.5 mm. The original first-generation formulas of the early 1980s, such as Binkhorst 2, are best described as 'single variable' formulas that use biometric measurement of axial length in their calculations.³ In 1988, the Holladay 1 formula added keratometry (K) readings to offer the first 'two variable' formula, which helped improve accuracy in short and long eyes. Over time, more robust diagnostic measurement of ocular structures allowed for more refined formulas to be developed. 'The only difference between today's and older formulas,' remarks Dr Holladay, 'is how we predict the effective lens position.'

Indeed, third-generation formulas, such as Holladay 1, Hoffer Q and SRK-T, each have their strengths and weaknesses, and their use has become segmented according to the specific eye type (short, medium or long) to which each is best-suited. These formulas assumed that the anterior segment size was directly related to axial length. This assumption resulted in 'surprise' outcomes, especially in short eyes.

The Role of Effective Lens Position

The Haigis formula (circa 1991) uses ACD and axial length as two variables to predict the effective lens position (ELP). One limitation of the Haigis formula is that to be 'optimised' it requires a large data set of several hundred of the surgeon's cases and further optimisation requires the use of an Excel spreadsheet. In 2010, the IOLMaster 500, released by Carl Zeiss Meditec Inc., included optimisation of the Haigis formula within the device, which reduced to 50 the number of cases that a surgeon needed to input to use the formula effectively.

In 1993, Dr Holladay led a worldwide study that involved 34 cataract surgeons to determine which of seven variables were relevant as predictors of ELP. In addition to axial length (now measured optically) and K readings, data were collected on horizontal white-to-white (WTW), refraction, ACD, lens thickness and patient age at time of surgery. The 2 % incidence of short eyes in the population required a large data set of 34,000 eyes, which was collected and analysed to determine the relative significance of each variable, as shown in *Table 1*. 'We were surprised to learn that horizontal white-to-white measurements emerged as the next most important variable relate to effective lens position after axial length and keratometries,' remarked Dr Holladay. 'We also proved that there is almost no correlation between axial length and size of the anterior segment in 80–90 % of eyes.'

The results from this study led to the release of the Holladay 2 formula and an easy-to-use programme that allowed for data entry of the new variables and instant calculation of ELP and the appropriate IOL power selection. It also led to a new paradigm of evaluating eyes by both their axial length (short, normal and long) and their anterior segment size (small, normal and large). In essence, there are now nine eye types – not just three – that could be used to classify a given patient’s eye,⁴ as shown in *Figure 1*. The WTW measurements demonstrate that normal axial length eyes (21–26 mm) had an equal distribution of eyes of either large (2 %) or small (2 %) anterior segment size. In short axial length eyes (<21 mm), 80 % would be considered normal and 20 % would be considered small in terms of anterior segment size. In eyes of long axial length (>27 mm), Dr Holladay commented that ‘effective lens position is much less a factor than obtaining an accurate axial length measurement in the first place, because the intraocular power is so low.’ Following this study, there are now 17 independent, peer-reviewed, published studies that show improved accuracy with the Holladay 2 formula.

Impact on Modern Cataract Surgery

‘For the first time we understood clearly why cataract surgeons were struggling to gain “refractive-like” outcomes on a more consistent basis,’ added Dr Holladay. ‘This study showed that the more you know about the anatomy, the better you can predict the outcome. But, you must automate your measurements to get the benefits of the precision of the formula.’

Holladay 2 has emerged as the ‘state-of-the art’ IOL calculation formula and today is the leading formula used by US surgeons.⁵ With over 11,000 IOLMaster devices in use worldwide, Carl Zeiss Meditec Inc. has now made it a priority to increase access to this formula by integrating it directly into the IOLMaster itself. Until now, using Holladay 2 required transfer to an external computer as well as purchase of a separate software package.

Through an exclusive agreement with Dr Holladay, IOLMaster users can now upgrade their IOLMaster and do calculations within the device, and so eliminate the need to transfer data to an external computer and to purchase a separate software package. While other systems still require data transfer to a PC to gain access to the Holladay 2 formula, Dr Holladay confirmed that ‘the IOLMaster 500 is the only instrument on the market that has the Holladay 2 formula inside the unit.’

Summary

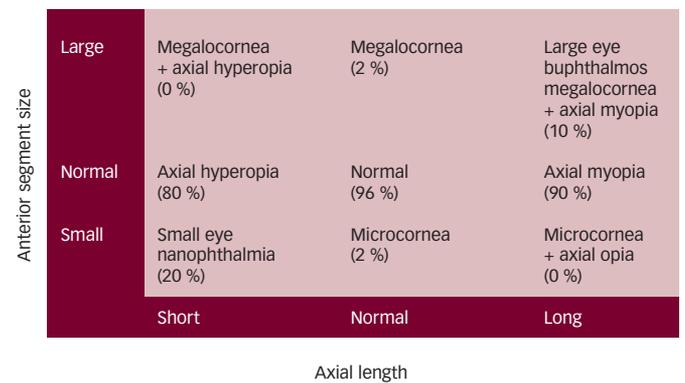
Improvements in technology have allowed the accuracy of cataract surgery to double every 5–10 years.⁶ The IOLMaster device and the

Table 1: Relative Importance of Variables Affecting Intraocular Lens Calculation

Rank	Variable	Relative Significance
1	Axial length	100
2	Average K	76
3	Horizontal WTW	24
4	Refraction	18
5	Anterior chamber depth	8
6	Lens thickness	7
7	Age	1

K = keratometry; WTW = white-to-white. Data from a worldwide study of 34,000 eyes. Source: Jack Holladay.

Figure 1: Categorisation of Eyes According to Axial Length and Anterior Segment Size



Data from a worldwide study of 34,000 eyes. Source: Jack Holladay.

Holladay 2 formula are key contributors to this trend. Current surveys suggest that eight of 10 surgeons use the IOLMaster platform, yet only three of 10 surgeons use the Holladay 2 formula. The fact that Zeiss has now ‘married’ them into the same box will only help increase access to the Holladay 2 formula. ‘I’m gratified that a much larger population of surgeons and their patients will benefit from the improved accuracy of IOL power calculations by having direct access to the Holladay 2 formula,’ concluded Dr Holladay.

As more and more surgeons face increasing demands on their time and skills because of an ageing population (that often also has higher expectations of their cataract outcomes than in the past), the convenience offered by this upgrade will have a positive impact on clinic workflow and the overall reputation of the ophthalmic surgical practice. ■

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