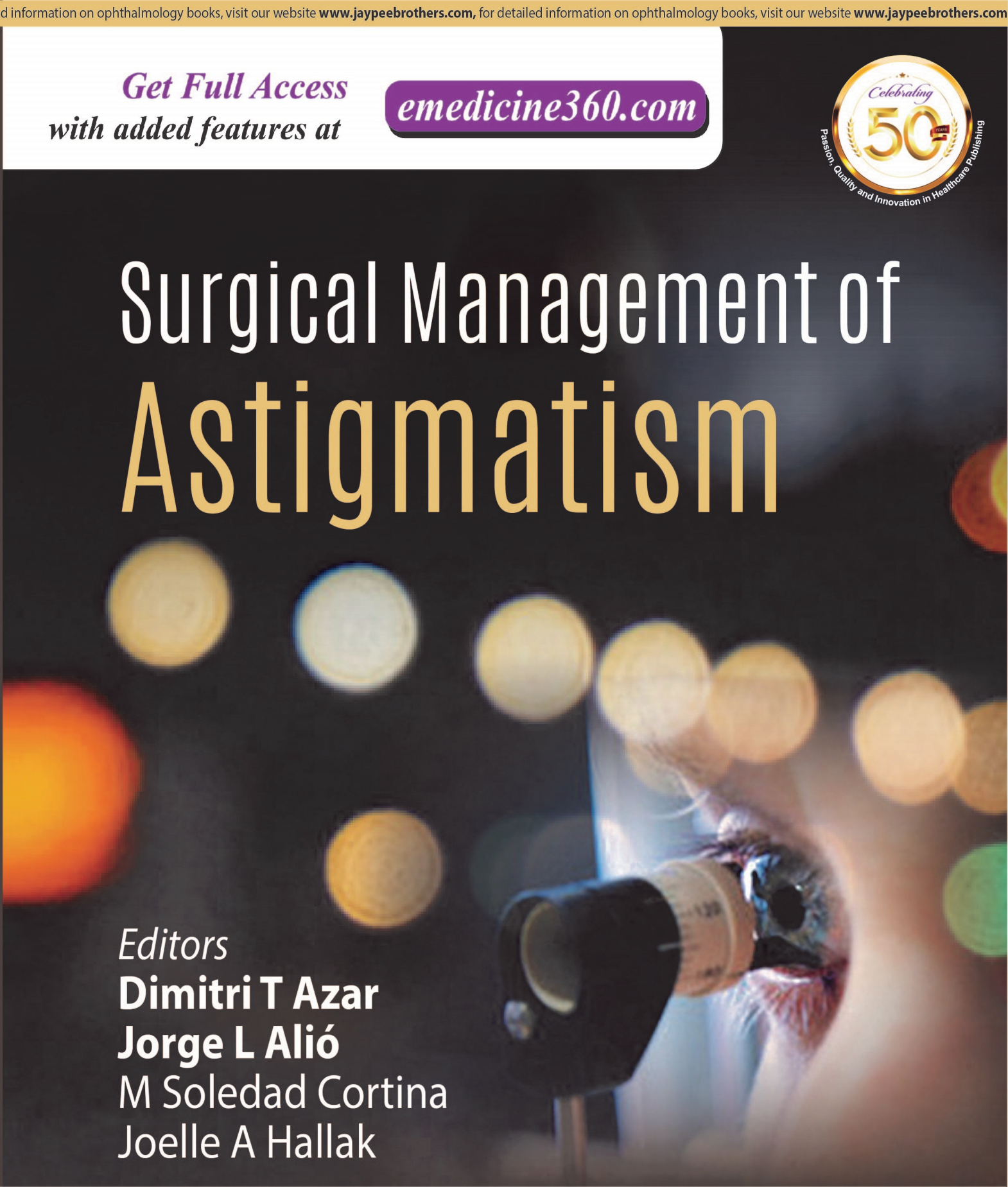
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# Surgical Management of Astigmatism



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# CHAPTER 3

# Optical Clinical Assessment of Astigmatism, Surgical Vector Planning, and Analysis of Astigmatism for Refractive Surgery

*Noel Alpins, George Stamatelatos*

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## CORE MESSAGES

- With advances in technology, the measurement of astigmatism now includes measurement of the posterior corneal astigmatism as well as calculation of ocular residual astigmatism.
- The anterior corneal astigmatism can be measured using a manual keratometer and a topographer.
- The total corneal astigmatism, which includes the posterior contribution, can be measured using a tomographer, optical coherence interferometers, and an auto keratometer.
- Manifest, cycloplegic, and wavefront refractions are used for measuring the refractive cylinder.

## INTRODUCTION

Astigmatism can occur at many different levels in the human eye. This can include the anterior and posterior cornea, the physiological lens inside the eye, retinal tilt at the back of the eye, and processing in the visual cortex. Correction of astigmatism can be performed in a number of ways: spectacles, toric contact lenses (soft and gas permeable), astigmatic keratotomy, excimer laser surgery, toric intraocular lenses (IOLs), and limbal relaxing incisions (LRIs). Accurate correction requires precise measurement of both refractive and corneal astigmatism together with an understanding of what exactly is being measured.

## OPTICAL CLINICAL ASSESSMENT IN ASTIGMATISM SURGERY

With advances in technology, the measurement of astigmatism has been elevated to a new level; this includes measurement of the posterior corneal astigmatism as well as calculation of ocular residual astigmatism (ORA). The ORA is the vectorial difference between corneal astigmatism and the refractive cylinder at the corneal plane and is expressed in diopters **(Fig. 3.1)**.[1,2]

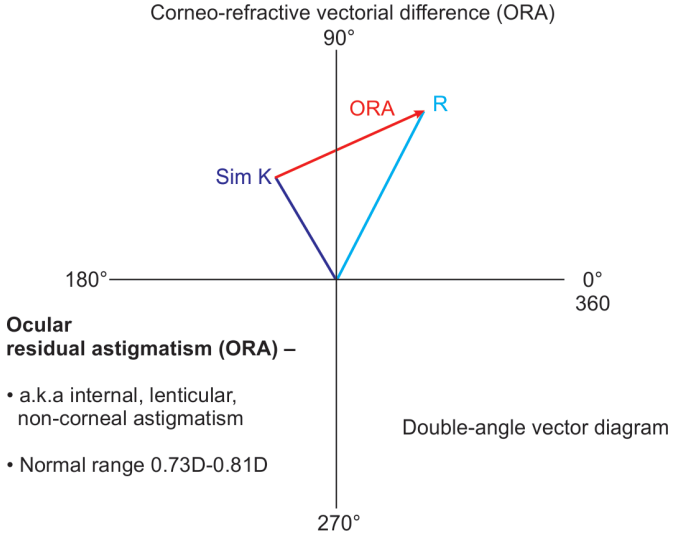



**Fig. 3.1:** The ocular residual astigmatism is the vectorial difference between the corneal astigmatism and the refractive cylinder at the corneal plane. (Sim K: simulated keratometry).

## Corneal Astigmatism

The anterior corneal astigmatism can be measured using:

i. A manual keratometer—measures at a corneal diameter of 3.2 mm. Distorted mires can indicate a dry corneal surface, in which case lubricating drops before measurement may be advised for greater accuracy. Furthermore, distorted mires on the manual keratometer can indicate corneal irregularity and detection of keratoconus. A skilled user can accurately determine the corneal astigmatism magnitude and meridian even for low amounts of astigmatism between 0.50 and 0.75 D.

ii. A topographer—measures the anterior corneal surface and presents much more detail and information than a manual keratometer. It calculates a simulated keratometry (Sim K), which is comparable to the manual keratometer measurement at a central 3-mm region of the cornea. For accurate corneal topography measurements, the eyelids must be outside the corneal diameter and the tear film at an optimum. Many topographers display the accuracy of the acquisition using a tick or a cross and indicate why the acquisition was not accurate. Simulated keratometry can vary, particularly with the determination of the steep meridian, and does not offer the technician any control over the measurement apart from lubricating the eye and keeping the eyelids clear of the cornea during acquisition.

    Many topographers such as the iTrace (Tracey™ Technologies) and the Nidek OPD III (Nidek Co., Ltd) calculate the internal astigmatism as well as the source of ocular aberrations.

    The total corneal astigmatism, which includes the posterior cornea contribution, can be measured using:

iii. A tomographer—measures both the anterior and posterior corneal shape as well as the thickness. Calculations of total corneal astigmatism are displayed and can be used for accurate toric IOL calculations of how much and in what direction the astigmatism needs to be neutralized. The total corneal astigmatism can also be used in LRI surgery and excimer laser surgery where the treatment plan incorporates the corneal astigmatism.

    It is important to note that the measure of corneal astigmatism does not always fall within exactly 3–4 mm of the central cornea as this varies depending on whether the cornea is very flat or steep. With a steep cornea, the measure of astigmatism will occur at a zone <3 mm and for a flat cornea at a zone more than 4 mm.

iv. Optical coherence interferometers—measure axial length using light instead of ultrasound.
    a. IOLMaster 700—uses "telecentric keratometry," which is a distance-independent approach that allows repeatable measurements. It uses six points to measure keratometry within a diameter of 2.3 mm. At the same time, this biometry device can acquire a reference image and data can be transferred to the Zeiss Callisto eye® (imaging) system on the surgical microscope for markerless alignment of toric IOLs in cataract surgery.
    b. Lenstar LS 900—measures at two zones—at 2.3 and 1.65 mm—using two rings, each ring containing 16 lights.

v. Autokeratometer—can measure at corneal diameters ranging from 2.5 to 3.3 mm and are both patient and examiner objective.

## Corneal Topographic Astigmatism

Instead of using measurements from a limited section of the cornea to determine the corneal astigmatism, the corneal topographic astigmatism (CorT) uses all the acquired data and vectorially calculates the anterior corneal astigmatism magnitude and meridian as well as the total corneal astigmatism in cases in which the posterior corneal measurement is included **(Fig. 3.2)**.[3,4] Use of all the acquired data reduces the possibility of selecting an irregular section of the cornea and basing the corneal astigmatism only on this one affected area. Using tomographers such as the CSO Sirius, the Oculus Pentacam, and the Ziemer Galilei, the total corneal astigmatism can be measured and the CorT total can be calculated, which includes the posterior corneal contribution.

Both CorT anterior and CorT total have been shown to be more accurate measures of corneal astigmatism compared with Sim K, manual keratometry, corneal wavefront, and paraxial curvature matching. The CorT parameters are calculated using the iAssort software, which is compatible with the Keratron Scout, Humphrey Zeiss Atlas, Nidek OPD III, Topcon CA-200, CSO Sirius, Oculus Pentacam, and Ziemer Galilei.

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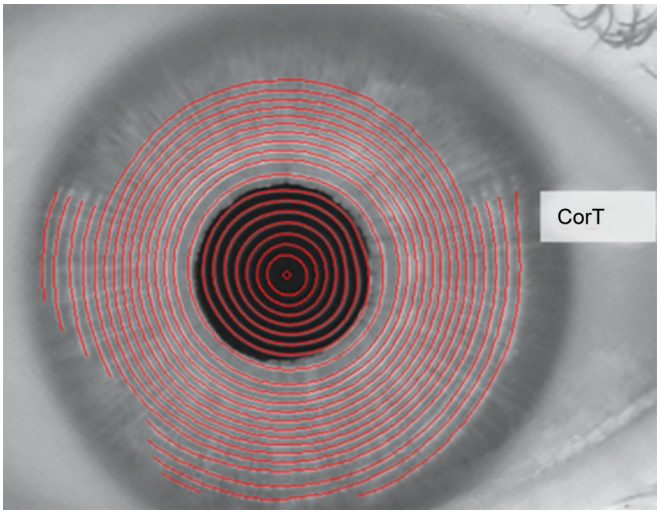



**Fig. 3.2:** The CorT incorporates all the acquired data. The CorT anterior is calculated using anterior corneal parameters alone and the CorT total uses both the anterior and posterior corneal curvatures. (CorT: corneal topographic astigmatism).

## Refractive Cylinder

1. Manifest refraction—the gold standard for measuring the refractive cylinder as it includes the optical system of the eye as well as the cortical perception.
2. Cycloplegic refraction—in most cases this is the same as the manifest refractive cylinder excluding the perceptual component. The cycloplegic refraction is useful in hyperopic excimer laser treatments to manifest any latent hyperopia.
3. Wavefront refraction—the second-order sphero-cylinder measurement here should always be confirmed with the manifest refractive cylinder.

It is left to the surgeon's discretion as to which measure of astigmatism is used in planning for the surgical correction of astigmatism. It is common to compare many of the measures and remove outliers but ultimately one must understand what part of the eye is being measured by the method selected. Using the ORA as a guideline can be helpful with the principle that a minimum ORA magnitude will give you the best measure of corneal astigmatism given the manifest refraction is the gold standard for the total astigmatism of the eye and its perception. In some surgical procedures, such as excimer laser surgery and intracameral lens implantation, both the refractive and corneal astigmatism parameters can be incorporated using the method of "The symptoms of glare, ghosting, starbursts, halos and reduced contrast sensitivity after refractive laser surgery commonly termed GASH is prevalent in cases where the ORA is greater than 1.00 D preoperatively and the corneal astigmatism postoperatively is consequently also greater than 1.00 D. Basing the treatment on refractive parameters alone such as manifest or wavefront refraction, can result in excess corneal astigmatism postoperatively. The method of Vector Planning should be used to systematically incorporate corneal parameters into the refractive treatment plan so that for eyes at risk with elevated ORA's will be in "low astigmatism" mode with less risk of developing what is collectively known as "PALS" Syndrome: Predictable (by calculating the ORA pre-op), Avoidable (by using Vector Planning to result in less overall corneal astigmatism postop, LASIK, Surprise (unexpected GASH). Many patients have written letters to the FDA and more recently to the New York Times in response to their article June 2018, complaining of astigmatism or one or more of these distressing symptoms".

## TAKE-HOME PEARLS

- It is important to note that the measure of corneal astigmatism does not always fall within exactly 3–4 mm of the central cornea as this varies depending on whether the cornea is very flat or steep.
- With a steep cornea, the measure of astigmatism will occur at a zone <3 mm and for a flat cornea at a zone more than 4 mm.
- Use of all acquired data for astigmatism reduces the possibility of selecting an irregular section of the cornea and basing the corneal astigmatism only on the affected area.
- Comparison of several methods for measuring astigmatism is recommended in planning the surgical correction.

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# Surgical Management of Astigmatism

***Salient Features***

- Provides an academic approach to the study of astigmatism and serves as a practical clinical reference for the surgical management of astigmatism
- Represents a true collaboration between editors and authors
- Provides various solutions and tailored techniques for diagnosing and managing regular and irregular astigmatism
- Discusses all the different methods to understand and manage astigmatism from laser surgery to incisional and intraocular lenses
- Describes new diagnostic technology, patient selection, procedures and limitations across applications
- Includes figures and illustrations to provide a comprehensive review.

**About the Editors**

The editors and authors of this book comprise a mosaic of experts in cornea, cataract, and refractive surgery. They are leaders, clinicians, scientists, biostatisticians, and engineers, collaborating to advance our understanding of the diagnosis and treatment of astigmatism.

The editors highlight work across disciplines contributed to the management of astigmatism. The contributing authors share their experiences and knowledge in tackling this complex disease. Their continuous dedication to best practices and to medical education is exemplary. This distinguished group of international contributors has captured the worldwide trends for the management of astigmatism, which has enabled this book to be a truly international book.

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