Review Article

Managing Corneal Astigmatism

Stephanie Watson OAM (BSc, MBBS, FRANZCO, PhD, GAICD, FARVO)

Professor, Corneal Research Group, Save Sight Institute, Faculty of Medicine and Health, The University of Sydney, Sydney, Australia.

Abstract

Corneal astigmatism is a refractive error that creates an asymmetric blur in the vision. Corneal astigmatism can arise from trauma, disease, following surgery, or be congenital. In assessing corneal astigmatism, a decision should be made as to whether the astigmatic pattern is regular or irregular. Regular astigmatism is most common, can be congenital and is easier to manage due to the uniform nature of the changes in corneal power. Irregular astigmatism is commonly caused by trauma disease and may be induced by surgery. Corneal astigmatism can sometimes be prevented or its magnitude or irregularity reduced. Using sealants following corneal trauma can reduce suture-induced astigmatism. Management options for corneal astigmatism include glasses, contact lenses, and surgery such as incisional procedures, refractive laser surgery, intraocular lenses or rarely corneal grafting. In children with corneal astigmatism, management of amblyopia is often needed. For keratoconus, which is often a cause of irregular astigmatism, corneal cross-linking should be considered to stabilize progressive disease prior to refractive management. New treatment modalities are needed to enable more patients with corneal astigmatism to have improved vision.

Keywords: Cornea, Astigmatism, Keratoconus, Laser surgery, Contact lenses.

Introduction

Corneal astigmatism blurs vision as it induces an asymmetrical refractive error. Corneal astigmatism can be present from birth (congenital), may follow trauma, be due to diseases such as keratoconus, and can complicate surgical outcomes. Corneal refractive power can be measured with topography and tomography and centrally is described as having a steep and flat meridian. The refractive power is derived from the anterior and posterior corneal shape and its thickness. The anterior corneal surface is responsible for the greatest proportion of refractive power as it interfaces with air. There has been increasing interest in the refractive power of the posterior corneal surface, particularly as it as it may impact outcomes following toric intraocular lens implantation.[1]

Classification of corneal astigmatism may be based on the uniformity of the corneal refractive power. With corneal astigmatism classified as regular if corneal refractive power varies uniformly, and irregular when the variations in power are not uniform. Management options for corneal astigmatism include spectacles, contact lenses and/or surgery. The appropriate management option to select for a patient depends on their visual needs and potential, age, co-existent ophthalmic and medical conditions, the underlying cause of the astigmatism, and whether it is regular or irregular.

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Causes of Corneal Astigmatism

Corneal trauma

Corneal trauma is a common cause of corneal blindness and a silent epidemic in developing countries as a superficial corneal injury can be complicated by infection and/or scarring due to delayed and inappropriate treatment.[2-4] In developed countries, falls in the elderly and alcohol-related assaults are associated with ocular trauma.[5] Astigmatism following trauma can result from direct injury to the cornea and following corneal repair, such as with sutures.

Surgery

Cataract surgery, laser and incisional refractive procedures, keratectomy for example, with pterygium removal and corneal grafting are surgical procedures that can all result in corneal astigmatism. Irregular astigmatism most commonly arises if ectasia or scarring complicates refractive surgery

Address for correspondence: Stephanie Watson OAM, Professor, Corneal Research Group, Save Sight Institute, Faculty of Medicine and Health, The University of Sydney, Sydney, Australia.
E-mail: stephanie.watson@sydney.edu.au

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and keratectomy and is not uncommon after penetrating keratoplasty. Cataract surgery can lead to surgically induced astigmatism; the magnitude and the magnitude of surgically induced astigmatism may decrease for steep-meridian incisions and increase for flat-meridian incisions.[6]

Corneal and ocular surface disease

Keratoconus is the most common corneal condition to produce corneal astigmatism, which is often irregular due to the inferior to superior refractive power asymmetry that characterizes the disease.[7] Patients with keratoconus suffer with reduced vision and photophobia and a quality of life that is worse than that for macular disease.[8] Ocular surface disease can affect the tear film, and changes in the tear film can contribute to an uneven refractive power, inducing or exacerbating astigmatism.[9]

Congenital astigmatism

Astigmatism may be present from birth and occur with myopia or hyperopia. In many children, astigmatism is low and does not necessarily require correction.[10] Though in patients presenting for cataract surgery, rates may be higher and there may be need for toric intraocular lens implantation.[11,12] In males, against the rule, astigmatism has been found to be greater and to have an earlier onset. This highlights that changes in astigmatism can occur over time and should be considered, along with gender, when planning astigmatic correction surgery.[13]

Classification of Corneal Astigmatism

Corneal shape and refractive power are described in terms of a flat and steep meridian. Corneal astigmatism is classified as regular or irregular depending on the uniformity across and between the meridians.

Regular astigmatism is the most common type of corneal astigmatism and is when consecutive variation in refractive power is from one meridian to the next (Figure 1). Each meridian has a uniform curvature at every point across the entrance pupil. Regular astigmatism can be further classified as 'with-the-rule' where the vertical meridian at 90 degrees is the steep meridian, or 'against-the-rule' where the horizontal meridian at 180 degrees was steepest or 'oblique' where the principal meridians are neither at 90 or 180 degrees.

Trauma is a common cause of irregular astigmatism. In irregular stigmatism, the principal meridansare at any angle aside from 90 degrees to each other, and each meridian's curvature is not uniform (Figure 2). Following trauma visual recovery is linked to the length of the wound; with a wound 1 to 4 mm long 50% will achieve 6/12 but if greater than 4 mm only 20% achieve 6/12 and there is typically greater than 3D of astigmatism. The pattern of astigmatism has been reported to be bowtie in 50%, spherical or oval in 36% and irregular in 14%.[14-16]

Recently, posterior corneal astigmatism has been highlighted as having a role in refractive outcomes following cataract surgery.[17,18] Such astigmatism has been reported to be more common in men and with higher amplitudes of myopia.[19] Indeed, improved accuracy of the refractive outcomes after implantation of toric intraocular lenses in patients with higher anterior or posterior corneal curvature or with the rule or against the rule astigmatism (rather than oblique) has been reported when posterior corneal astigmatism has been considered.[17,18]

Prevention of Corneal Astigmatism

In some cases, it may be possible to take measures to avoid inducing astigmatism or reduce the magnitude or non-uniformity of the astigmatism. For example, to prevent astigmatism after corneal trauma, smaller wounds (less than 2 mm) can be managed with bandage contact lenses or glue

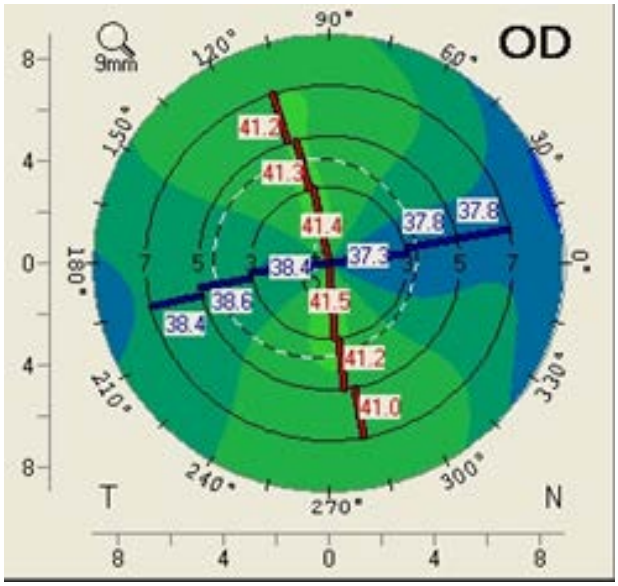

Figure 1: Corneal topography demonstrating regular astigmatism

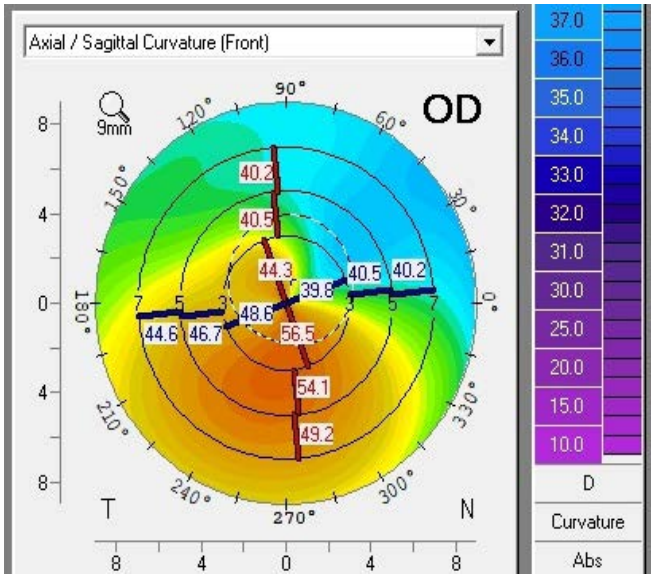

Figure 2: Corneal topography demonstrating irregular astigmatism in keratoconus

to avoid suture-related astigmatism (Figures 3 and 4).[20,21] If sutures are needed, suture length and placement should be optimized to reduce inducing astigmatism. With cataract surgery, consideration can be given to operating on the steep-meridian as this may reduce the magnitude of surgically induced astigmatism.[6] Post-operative suture management following deep anterior lamellar or penetrating keratoplasty can be used to manage astigmatism; sutures on the steep axis can be removed to flatten the cornea in that meridian.

Management of corneal astigmatism

Management of corneal astigmatism can involve use of spectacles, contact lenses and/or surgery. In some cases, if the visual acuity meets a patient's visual needs or the fellow eye has good vision, no further management may be needed. In children, therapy to manage amblyopia such as patching often accompanies the management of the astigmatic error.

Regular astigmatism can be left uncorrected if small and visual acuity is adequate to meet the patient's needs. If correction is required to improve vision, glasses, soft contact lenses, toric intraocular lens, incisional corneal surgery, and laser refractive surgery are options. With irregular astigmatism rigid gas permeable or scleral contact lenses can be trialed. If conservative measures fail in some cases a corneal graft maybe needed. Photo-therapeutic keratectomy (PTK) maybe suitable for superficial scars of recent onset. Success rates of photo-therapeutic keratectomy for corneal scarring are reported to be around 60%, with topographically guided treatments aiming to improve treatment outcomes.

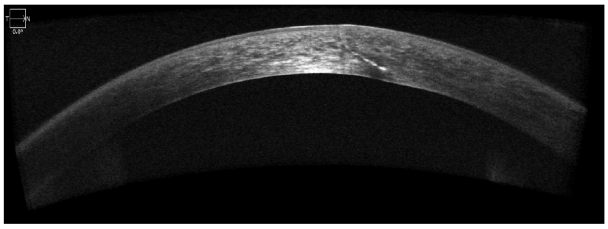

Figure 3: Central corneal scar following trauma. The wound was left to self-seal to avoid suture-induced astigmatism. Final visual acuity 6/6.

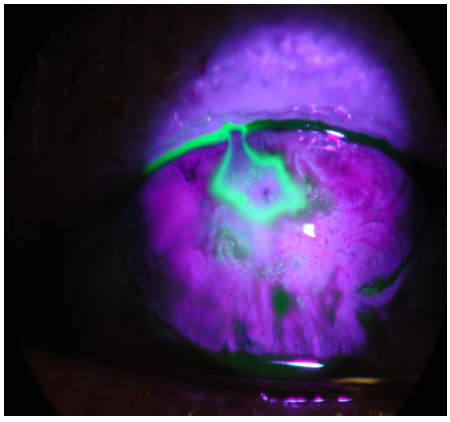

Figure 4: Small corneal wound with minimal tissue loss suitable for treatment with corneal gluing

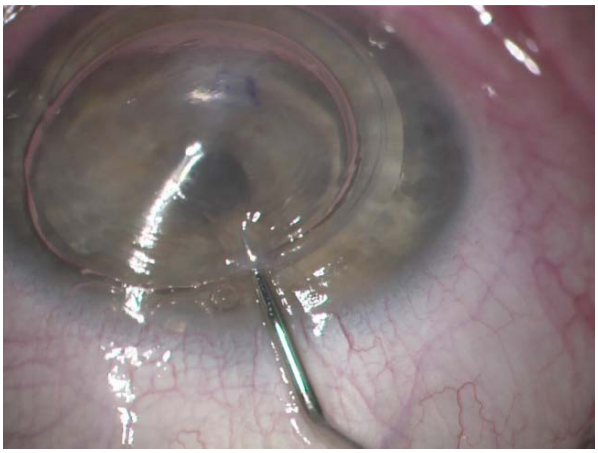

Figure 5: Deep anterior lamellar keratoplasty for corneal scarring

Corneal grafting techniques to manage astigmatism include deep anterior lamellar keratoplasty (Figure 5) and penetrating keratoplasty. Deep anterior lamellar keratoplasty has been recommended in keratoconus to reduce the risk of rejection and may have a tectonic advantage.[22,23] Deep anterior lamellar keratoplasty may also be used to manage deep corneal scars such as post-infectious scarring. When there is endothelial involvement, a penetrating keratoplasty may be considered.

Intraocular lens surgery has also been used to address corneal astigmatism. Toric intraocular lenses can be implanted when the astigmatism is regular and stable.[11,12,24] (Table 1) with consideration given to posterior corneal astigmatism.[1,17,19] Recently, pinhole devices have been introduced for irregular astigmatism but may affect visual fields and dim vision.[25,27] Pinhole devices include secondary piggyback lenses. In one case series, 11 pseudophmic eyes had a secondary piggyback pinhole device inserted. Median uncorrected distance visual acuity increased from 0.7 log MAR to 0.4 and 72% satisfaction related. Two patients, however, had the device explanted due to glare and floaters.[25,28]

For patients with keratoconus, there is a greater risk of progression with steeper corneas and younger age.[29,30] For these patients prior to spectacles or contact lenses, corneal cross-linking should be considered to stabilize corneal astigmatism and improve quality of life.[31,32]

New Directions in Managing Corneal Astigmatism

Despite the range of treatments available for corneal astigmatism, many patients remain untreated due to the limitations of current treatments. In the future, stem cell-

Table 1: Summary of the indications for use of a toric vs non-toric intraocular lens in corneal astigmatism. (IOL = intraocular lens)

Patient characteristic	*Non-toric IOL*	*Toric IOL*
Irregular astigmatism	X	
Apical scarring	X	
Stable refraction		X
Spectacle VA good		X

based therapies hope to regenerate corneal shape and structure. Initial studies of mesenchymal stem cells have reported positive outcomes, such as an increase in vision in advanced keratoconus.[33] Corneal sealants will likely also have a role in reducing the need for sutures.[20,21] Finally, collecting patient-reported outcomes in assessing the benefit to patients of new and existing treatments will be important.[34]

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