Management of pre-existing regular astigmatism in phacoemulsification

essay submitted for partial fulfillment of
Master degree in ophthalmology

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Optics of astigmatism

Astigmatism is a refractive error in which the power of the astigmatic eye varies in different meridians where the image is formed as a Sturm's conoid, thus it decreases visual acuity by forming a distorted image because light images focus on two separate points in the eye. **(Elkington et al, 1999)**.

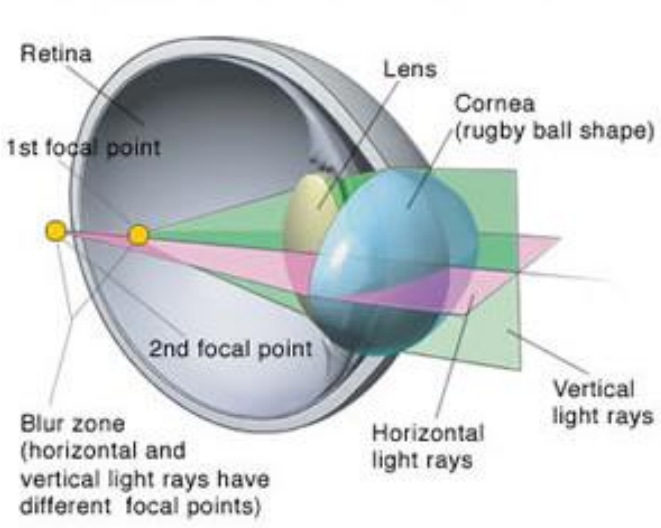

Figure 1.Cross section of astigmatic eye.(www.ico.com)

Astigmatism occurs when toricity of any of the refractive surfaces produce two principal foci delimiting an area of intermediate focus. It may be naturally occurring, develop after injury, occur with excessive eye rubbing, indicate underlying disease such as keratoconus, and other corneal ectasias, corneal basement membrane and stromal dystrophies, corneal scarring, and post-surgical corneas (e.g., following penetrating keratoplasty, radial keratotomy (RK), complicated refractive surgery). **(Guillermo et al, 2006)**

An astigmatic surface can not bring a pencil of light rays to a point focus. Instead, two focal lines are formed. The complicated geometrical

envelope of a pencil of light rays refracted by astigmatic surface is called *The Conoid of Sturm*. **(Miller et al., 2004).**

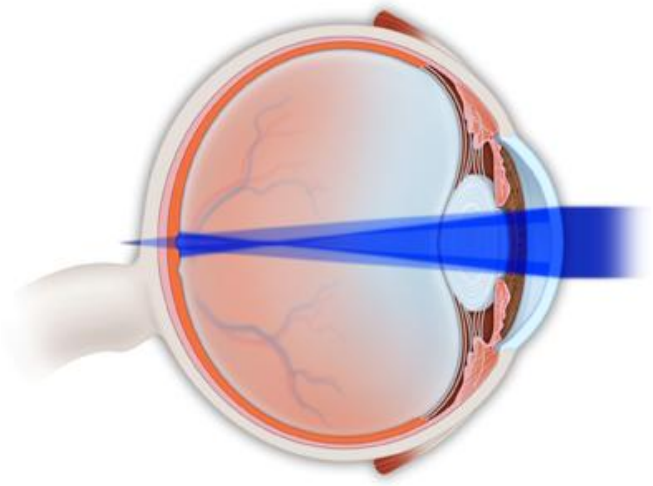

Figure 2.The Conoid of Sturm. . (www.ico.com**)**

CLASSIFICATION OF ASTIGMATISM

Astigmatism may be classified in a number of ways. It is important to identify the type of astigmatism present before considering any corrective treatment. **(Poon and Taylor, 2001)**.

I. According to regularity, astigmatism is classified into:

a) **Regular astigmatism**- The meridians of maximum and minimum curvature are at right angles to each other. In this condition, the principal meridians of astigmatism have constant orientation at every point across the pupil, and the amount of astigmatism is the same at every point. The blurred retinal image can be improved with an appropriate cylindrical correction. **(Miller et al., 2004).**

b) **Irregular astigmatism**- Astigmatism is termed Irregular when the two principal meridians of curvature are not 90 degrees apart or the corneal curvature is not axially symmetric. The orientation of the

principal meridian, and thus, the amount of astigmatism changes from one point to another. **(El-Rifai**, 2004).

Regular	Irregular
• Two identifiable principal meridians separated by 90º. • Excellent best spectacle corrected visual acuity to 20/20. • Distinct end point on keratometry. • Symmetric bow-tie pattern on corneal topography. • Congenital or acquired.	• Principal meridians separated by angle other than 90º. • Best corrected visual acuity is achievable with hard contact lenses. • Keratometry mires can be superimposed. • Lack of symmetry or regularity on corneal topography. • Usually acquired.

Table 1.Criteria of regular and irregular astigmatism. (Camposand McDonnell, 1999).

II. <u>According to the position of principal meridians, regular astigmatism can be classified into:</u>

a) **Straight astigmatism**– The major and minor meridians are one horizontal and one vertical and both are at right angle.

b) **Oblique astigmatism**– The major and minor meridians are oblique (more than 10 degrees away from the 90- and the 180- degree meridians), but at right angle.

c) **Bi-oblique astigmatism**– The major and the minor meridians are oblique and are not at right angle but with regular gradual changes in-between.

III. **Regarding the rule of regular astigmatism, astigmatism is referred to as**:

a) **With-the-Rule astigmatism (WTR)** - The more common type in young people; where the vertical meridian is the steepest (has the greatest power), and a correcting plus cylinder should be used at or near axis 90º. **(Miller et al., 2004).**

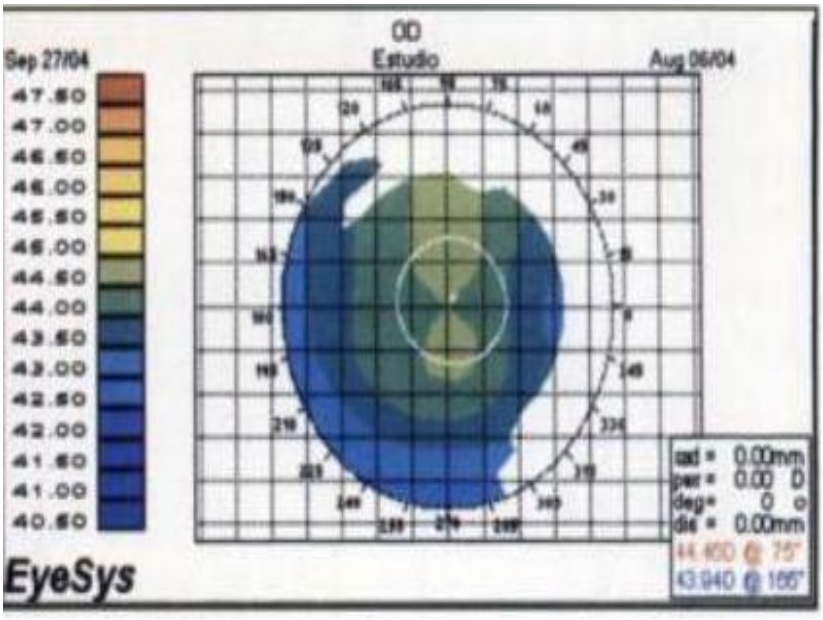

Figure 3:Regular "with-the-rule" astigmatism (Guillermo et al, 2006)

b) **Against-the-Rule astigmatism (ATR)**- The more common type in elder adults; here the horizontal meridian is the steepest, and a correcting plus cylinder should be used at or near axis 180º**.(Miller et al., 2004).**

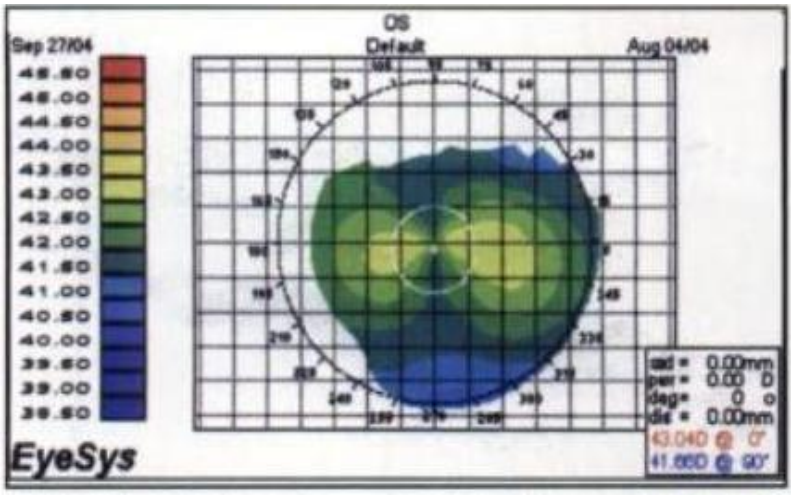

Figure 4: Regular "against-the-rule" astigmatism. (Guillermo et al, 2006)

a) **Symmetric astigmatism**– in which there is a symmetrical position of deviation of the principal meridians from the median line with their axes of the same sign and together equal 180º (e.g., 20º in the right eye and 160º in the left eye).

b) **Asymmetric astigmatism**– there is no symmetry in the relationship of the principal meridians to the median line (less common than symmetric).

V. In association with the spherical refractive errors, regular astigmatism is classified as follows:

a) **Simple astigmatism**– one meridian is emmetropic while the other meridian at right angle is ametropic:

1. **Simple myopic astigmatism**- the rays in one meridian focus on the retina, while those in the other meridian focus anterior to the retina.
2. **Simple hyperopic astigmatism**- the meridian of maximum power is emmetropic, therefore; it forms a line image of a point on the retina. The meridian of minimum power is hyperopic, so it will form a vertical line image posterior to the retina.

b) **Compound astigmatism**– the two principal meridians are either myopic or hypermetropic:

1. **Compound myopic astigmatism**– the rays in all meridians come to focus anterior to the retina.
2. **Compound hyperopic astigmatism**– the rays in both meridians are focused posterior to the retina. Although accommodation will allow the movement of the line foci toward the retina, both line foci cannot be placed simultaneously on the retina.

Mixed astigmatism– one meridian is myopic and the other is hypermetropic, i.e.; the rays in one meridian come to focus anterior to the retina while those in the other meridian come to a focus posterior to the retina.**(El-Rifai, 2004).**

In order to thoroughly understand the refractive surgery procedures, one must have knowledge of the anatomy of the cornea. The cornea forms the anterior one sixth of the circumference of the outer coat of the eye. It is the most powerful refractive surface of the eye, providing 70% (40-45 diopter) of the eye's focusing power. **(Fischbarg, 1997).** It is somewhat oval and has an average diameter of approximately 11 mm vertically and 12 mm horizontally; giving rise to astigmatism with the rule. The radius of curvature of the cornea is slightly greater in the outer than in the inner surface. The thickness varies from about 0.56 mm in the center to about 1.0 mm at the periphery**.** ***(Cerulli and Missirolli, 2008)*****.**

The cornea is described as five layered structure: (figure 5):

1-epithelium (outermost layer)

2 anterior limiting lamina (Bowman's membrane)

3- stroma

4-posterior limiting lamina (Decemet's membrane)

5- endothelium (innermost layer)**(Bergmanson, 2001)**

Figure 5: transverse section through the cornea, which is bounded anterioly by stratified non keratinized epithelium and posterioly by a single layer of squamous endothelial cells. Stromal tissue occupies the space between these two layers. Within the stroma dense staining keratocytes more numerous anterioly may be noted. (Bergmanson, 2001)