

**Evaluation of the orientation of the steepest meridian of regular astigmatism among highly myopic Egyptian patients seeking non-ablative surgical correction of the refractive error**Tamer Adel Refai<sup>1</sup><sup>1</sup>MD, FRCS, Refractive Unit, Ophthalmology Department, Research Institute of Ophthalmology, Giza, Egypt**Type of article:** Original**Abstract**

**Introduction:** LASIK surgery is currently the preferred procedure to correct low to moderate myopia. The aim of this study was to determine the orientation of the steepest meridian of regular astigmatism in order to determine the relative incidence of vertical, horizontal, and oblique regular astigmatism among highly myopic Egyptian patients seeking non-ablative surgical correction of the refractive error.

**Methods:** One hundred and one eyes of 68 highly myopic patients who were seeking refractive surgery were included in this consecutive case series study. The refractive errors were measured using an autorefractometer and confirmed by trial. We measured the uncorrected and best corrected visual acuity in Snellen lines. Keratometry, central corneal thickness, and anterior chamber depth also were measured. The cylinder power in diopters and the axis in degrees were reported. Astigmatism was graded as with the rule (i.e., vertical meridian steeper), against the rule (i.e., horizontal meridian steeper), and oblique astigmatism. The number and the percentage of eyes with the rule, against the rule, and oblique astigmatism were calculated, and the chi-squared test was performed to analyze the data.

**Results:** The spherical refractive error ranged from -6.5 to -24.5 diopters ( $-13.45 \pm 4.60$ ). The cylinder power (Cyl) ranged from -0.25 to -7.5 diopters ( $-2.23 \pm 1.28$ ). The uncorrected visual acuity (UCVA) in Snellen lines ranged from 0.01 - 0.1 ( $0.03 \pm 0.02$ ). The mean for best corrected visual acuity (BCVA) in Snellen lines was 0.40 ( $\pm 0.23$ ). The steepest meridian was vertical (i.e., with-the-rule astigmatism) in 44 eyes (43.56%), horizontal (i.e., against-the-rule astigmatism) in 27 eyes (26.73%), and oblique (i.e., oblique astigmatism) in 30 eyes (29.70%).

**Conclusions:** The incidence of with-the-rule astigmatism in patients with high myopia was found to be much lower than in previous studies for non-myopic patients, with a higher incidence for against-the-rule astigmatism and oblique astigmatism.

**Keywords:** myopia, refractive error, steepest meridian, astigmatism, Egypt

**1. Introduction***1.1. Background and statement of the problem*

LASIK surgery is currently the preferred procedure to correct low to moderate myopia. After the surgery, the cornea will be thinner and flatter based on the extent of the intended correction. In performing LASIK surgery, the surgeon must ensure that the stromal bed is at least 250  $\mu\text{m}$ , and it is preferable if it is 15-20% greater than that. If these limits are violated, the risk of developing corneal ectasia (i.e. forward bulging of the cornea) is increased, which is associated with decreased visual quality. Currently, surgeons are tending to reduce the upper limits of LASIK and PRK to the range of -8 to -10 D to avoid the risk of higher-order aberrations (1). Corneal refractive surgery cannot be used to treat as large a range of myopic and hyperopic problems as can phakic intraocular lens (PIOLs), and the skills required to insert PIOLs generally are very similar to the skills required to perform cataract surgery. In addition, the equipment costs less than an excimer laser, and, if there is a need to change the refractive effect, the PIOL can be removed, albeit with some slight risk of permanent damage. Even so, extraction of the PIOL is more effective than extracting a clear lens because natural accommodation can be preserved, and preserving the

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crystalline lens with minimal vitreous destabilization lowers the risk of the retina becoming detached after the surgery (2). One of the most commonly used phakic IOLs in our institute is the non-toric iris claw phakic IOL, which is traditionally implanted through a superior corneal incision, which is the main route for inserting the PIOL (3, 4). There are three main types of regular astigmatism in which the principal meridians are perpendicular (5): 1) With-the-rule astigmatism: the vertical meridian is the steepest (resembling a rugby ball or an American football lying on its side), 2) Against-the-rule astigmatism: the horizontal meridian is the steepest (resembling a rugby ball or an American football standing on its end), and 3) Oblique astigmatism: the steepest curve lies between 120 and 150 degrees and 30 and 60 degrees. If the patient has with-the-rule astigmatism (i.e., the vertical meridian is the steepest), then the astigmatic error will be expected to be reduced after the surgery. However, if the patient has against-the-rule astigmatism (i.e., the horizontal meridian is the steepest) or oblique astigmatism, the astigmatic error will be expected to increase after the surgery. In one study performed in 2005 on patients with astigmatism whose ages ranged from 5 to 46, the incidence of with-the-rule astigmatism was 77.9%, the incidence of against-the-rule astigmatism was 17.7%, and 5% were in the oblique group (6). Also, in 1999, Alves found that with-the-rule astigmatism accounted for 77.5% of astigmatic errors (7), but neither of the studies was confined to highly myopic eyes.

### *1.2. Objectives*

The aim of this work was to evaluate the relative incidence of with-the-rule, against-the-rule, and oblique astigmatism among 101 eyes of 68 randomly-selected, highly-myopic, astigmatic patients who were treated in 2014 and 2015 in the Refractive Surgery Unit in the Research Institute of Ophthalmology (Giza, Egypt). We conducted this research to highlight the importance of changing the traditional location of the main incision for phakic IOL, particularly for the iris claw lens, which is the commonly performed refractive surgical procedure in the Institute. The aim of changing the location of the incision was to reduce the cylindrical refractive error while correcting the spherical refractive error for high myopia to provide the patients with the best possible outcome.

## **2. Material and Methods**

One hundred and one eyes of 68 highly myopic (more than -6 diopters) Egyptian patients in the Refractive Clinic of the Research Institute of Ophthalmology in Giza, Egypt, were included in this consecutive case series study. The patients had astigmatic errors and spherical errors and were not suitable candidates for ablative procedures. Female and male patients accounted for 64 and 37 of the eyes that were treated, respectively. The patients' ages ranged from 12-55 years (with a mean/SD of  $33.77 \pm 8.77$ ). For these patients, the refractive error was measured with an autorefractometer, model Topcon RM 5000, Japan, and confirmed by trial. The uncorrected and best-corrected visual acuities in Snellen lines were measured and reported. The Keratometry, central corneal thickness, and anterior chamber depth were measured by an ALLEGRO Oculyzer (Pentacam) Version 1074; Allergo, Germany. The cylinder power in diopters and the axis in degrees were reported. The astigmatism was graded as with-the-rule (i.e., vertical meridian steeper), against-the-rule (i.e., horizontal meridian steeper), and oblique astigmatism (i.e., when the steeper meridian deviates more than 30 degrees from either the vertical or horizontal meridians). The numbers and percentages of eyes with-the-rule, against-the-rule, and oblique astigmatism were calculated, and the chi-squared test was performed to analyze the data. We also reported the largest and smallest values, the mean value, and the standard deviation. The patients who were excluded from the study included those with irregular astigmatism; corneal scars and opacities; previous ocular surgery or trauma; keratoconus and related disorders; and autoimmune and systemic collagen disease, e.g., rheumatoid arthritis, Systemic lupus erythematosus (SLE), and ocular surface disease.

## **3. Results**

The spherical refractive error ranged from -6.5 to -24.5 diopters ( $-13.45 \pm 4.60$ ). The cylinder power (Cyl) ranged from -0.25 to -7.5 diopters ( $-2.23 \pm 1.28$ ). The uncorrected visual acuity (UCVA) in Snellen lines ranged from 0.01-0.1 ( $0.03 \pm 0.02$ ). The best corrected visual acuity (BCVA) in Snellen lines ranged from 0.02-1.0 ( $0.40 \pm 0.23$ ). The steepest meridian was vertical (i.e., with-the-rule astigmatism) in 44 eyes (43.56%), horizontal (i.e., against-the-rule astigmatism) in 27 eyes (26.73%), and oblique (i.e., oblique astigmatism) in 30 eyes (29.70%) (Table 1). Statistical analyses of the number of eyes with the three different types of regular astigmatism (with-the-rule, against-the-rule, and oblique astigmatism) among the highly myopic patients in the study and their comparison with expected numbers provided chi-squared statistics equal to "P = 3.56%" ( $p < 0.05$ ), denoting a statistically significant difference from the expected numbers.

**Table 1.** Actual number of eyes and their relative incidence in percentage (%) of with-the-rule, against-the-rule, and oblique astigmatism among the highly myopic patients in the study

Type of regular astigmatism	n	%
With-the-rule astigmatism	44	43.56%
Against-the rule- astigmatism	27	26.73%
Oblique astigmatism	30	29.70%

#### 4. Discussion

'High myopia' usually refers to myopia of  $-6.00$  or more (8). Roughly 30% of myopes have high myopia (9). Currently, the technique of choice to correct myopia is LASIK surgery, and one study (10) has indicated that this surgery has a success rate of 94%. Unfortunately, LASIK surgery cannot be performed for some patients for several reasons, e.g., their corneas are too thin and there is the potential for structural instability, ectasia and associated complications, loss of best spectacle-corrected visual acuity (BSCVA), and iatrogenic Keratoconus (11). In such situations, other treatments are available, including the implantation of phakic IOLs and the extraction of clear lens. The former has the advantage of preserving natural accommodation and may have a lower risk of postoperative retinal detachment because of the preservation of the crystalline lens and minimal vitreous destabilization (2). However, any procedure that involves a corneal incision can result in surgically-induced astigmatism, depending on the site and width of the incision. For example, astigmatism can be reduced significantly if the incision is made in the temporal meridian. Nasal and supero-temporal incisions induce greater degrees of astigmatism, perhaps because they are farther from the central cornea (12-15). The worst astigmatism occurs when incisions are made superiorly because such incisions are affected by several factors, including the blinking of the eyelids (16, 17). Also, the extent to which astigmatism occurs after surgery depends significantly on the width of the incision. All incisions flatten the meridian to some extent, and larger incisions increase this effect (18, 19-21). For the correction of high myopia by the extraction of the clear lens or by implanting a phakic implantable collamer lens (ICL), the reduction of pre-operative astigmatism can be achieved easily by placing the main incision on the steepest meridian. However for iris-claw lenses implantation (which are commonly used), the matter is more complicated, because in the standard protocol for implanting these lenses (i.e. iris claw lenses), the main incision for implanting the lens is always placed at 12 O'Clock position (22). This would be expected to be beneficial in reduction of preoperative astigmatism if the patient has with-the-rule astigmatism. On the other hand, it would be expected to worsen the preoperative astigmatism if the patient has against-the-rule or oblique astigmatism. Previous studies have indicated that with-the-rule-astigmatism accounts for the vast majority of cases of regular astigmatism (77.9% in one study (6) and 77.5% in other studies (7, 23). Thus, many refractive surgeons are not concerned about inducing post-operative astigmatism when they correct highly myopic errors with phakic IOLs. This is particularly the case when they are implanting iris-claw lenses through a superiorly-located main incision according to the standard protocol. The results of this study indicated that, for the 101 highly-myopic eyes with astigmatism for which non-ablative refractive surgery was recommended, 44 eyes (43.56%) had with-the-rule astigmatism, 27 eyes (26.73%) had against-the-rule astigmatism, and 30 eyes (29.70%) had oblique astigmatism. These results do not agree with the results obtained by Garcia on individuals between the ages of 5 and 46. In these patients, the incidences of with-the-rule and against-the-rule astigmatism were 77.9 and 17.7%, respectively. The minority, 5.0%, was in the oblique group (6), but Garcia's study was not confined to highly myopic eyes as this study was. According to this study, pre-operative astigmatism can be expected to be improved in only 43.56% of the cases of highly myopic eyes corrected by clear lens extraction or phakic IOL performed through a superior corneal incision. Unfortunately, the pre-operative astigmatism will be expected to exacerbate in 56.43% of the cases. Thus, it is important to take measures to improve astigmatism while correcting myopic errors because patients who seek surgical correction of refractive errors usually do not expect to have to wear glasses after the surgery. Therefore, according to the results obtained in this study, unless a toric IOL is used, the main incision for clear lens extraction and phakic IOL should always be at the steepest meridian in order to achieve astigmatic correction in addition to the spherical correction. For iris claw lens implantation in highly myopic patients with regular astigmatism other than with-the-rule astigmatism, the main incision for introducing the lens into the eye must be made on the steepest meridian. Then, the lens must be rotated to the horizontal position and an additional superior astigmatically neutral microincision must be made ( $< 1$  mm) using a 19 or 20 gauge MVR.

#### 5. Conclusions

The incidence of with-the-rule astigmatism in patients with high myopia was found to be much lower than in the previously mentioned studies for non-myopic patients. There were a corresponding higher incidences of against-the-rule and oblique astigmatism, so, unless a toric IOL is used, the incision site should be fashioned for the surgical

correction of myopia. This would include phakic IOL implantation to be in the steepest meridian even if this necessitates modifying the standard surgical protocol in order to achieve acceptable refractive results.

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**Conflict of Interest:**

There is no conflict of interest to be declared.

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