Arquivos Brasileiros de
Oftalmologia

ORIGINAL ARTICLE

# Prevalence of corneal astigmatism in cataract surgery candidates at a public hospital in Brazil

## Prevalência de astigmatismo corneano em candidatos a facectomia em hospital público no Brasil

Mara Barreto Theiss[1], Marcony R. Santhiago[1,2,3,4], Haroldo V. Moraes Jr[3], Beatriz Fiuza Gomes[1,2]

1. Department of Ophthalmology, Hospital Federal de Bonsucesso, Rio de Janeiro, RJ, Brazil.
2. Department of Ophthalmology, University of Southern California, USC, Los Angeles, CA, USA.
3. Department of Ophthalmology, Universidade Federal do Rio de Janeiro, Rio de Janeiro, RJ, Brazil.
4. Department of Ophthalmology, Universidade de São Paulo, São Paulo, SP, Brazil.

**ABSTRACT | Purpose:** To assess the frequency of corneal astigmatism before cataract surgery in a Brazilian sample. **Methods:** This clinic-based cross-sectional study was conducted at the Bonsucesso Federal Hospital, Rio de Janeiro, Brazil. Charts of patients who underwent cataract surgery over a two-year period were retrospectively reviewed, and preoperative keratometric measurements were collected and analyzed. **Results:** A total of 1707 eyes of 1045 patients were enrolled. The corneal astigmatism was less than 1.0 D in 971 eyes (56.9%), 1.0-1.99 D in 496 eyes (29.1%), 2.0-2.99 D in 157 eyes (9.2%), and more than 3.0 D in 83 eyes (4.9%). The mean corneal astigmatism was 0.92 ± (SD) 0.96 D (range 0 - 10.25 D). **Conclusion:** Over 40% of the patients undergoing cataract surgery enrolled in this study had more than 1.0 D of corneal astigmatism and may benefit from the use of toric intraocular lenses. These data can be useful for planning to make this technology available for patients.

**Keywords:** Astigmatism/epidemiology; Cataract extraction/adverse effects; Lenses, intraocular; Cross-sectional study; Brazil.

**RESUMO | Objetivo:** Avaliar a prevalência do astigmatismo corneano antes da cirurgia de catarata em pacientes brasileiros. **Métodos:** Este estudo transversal de base clínica foi realizado no Hospital Federal de Bonsucesso, Rio de Janeiro, Brasil. Os prontuários de pacientes submetidos à cirurgia de catarata durante um período de dois anos foram revisados retrospectivamente, e as medidas ceratométricas pré-operatórias foram coletadas e analisadas. **Resultados:** Um total de 1.707 olhos de 1045 pacientes foram incluídos. O astigmatismo corneano foi menor que 1,0 D em 971 olhos (56,9%), 1,0-1,99 D em 496 olhos (29,1%), 2,0-2,99 D em 157 olhos (9,2%) e mais de 3,0 D em 83 olhos (4,9%). A média do astigmatismo corneano foi de 0,92 ± (SD) 0,96 D (intervalo 0-10,25 D). **Conclusão:** Mais de 40% dos pacientes estudados submetidos à cirurgia de catarata incluídos neste estudo tinham mais de 1,0 D de astigmatismo corneano e podem se beneficiar do uso de lentes intraoculares tóricas. Esses dados podem ser úteis no planejar a disponibilização dessa tecnologia para os pacientes.

**Descritores:** Astigmatismo/epidemiologia; Extração de catarata/efeitos adversos; Lentes intraoculares; Estudo transversal; Brasil.

## INTRODUCTION

The preoperative assessment of patients with cataract should include corneal astigmatism (CA), and it should be addressed either at the time of cataract surgery or afterward to provide the best visual performance. Toric intraocular lens (TIOL) implantation during cataract surgery is considered an effective and safe method to reduce CA. However, in Brazil, the public health system only provides aspheric and spherical IOLs, limiting the options for astigmatism correction at the time of cataract surgery.

Studies about the distribution and frequency of CA in cataract patients from different countries have previously shown that a significant number of patients have a varying degree of preexisting CA[1-5]. Moreover, the frequency of astigmatism varies across racial/ethnic groups[6,7]. The population of Brazil is composed of several ethnic groups. Therefore, it would be interesting to determine the demand of astigmatism correction in

Submitted for publication: April 17, 2018
Accepted for publication: November 24, 2018

**Funding:** No specific financial support was available for this study.

**Disclosure of potential conflicts of interest:** None of the authors have any potential conflicts of interest to disclose.

**Corresponding author:** Beatriz Fiuza Gomes.

Hospital Universitário Clementino Fraga Filho. Departamento de Oftalmologia

Rua Prof. Rodolpho Paulo Rocco, 255 - 11º andar - Rio de Janeiro - RJ - 21941-913 Brazil - E-mail: exopina@hotmail.com

**Approved by the following research ethics committee:** Hospital Federal de Bonsucesso (#58200716.50005253).

cataract surgery for our population rather than using international data.

To investigate the frequency of CA, this study reviewed all cataract cases over a two-year period from a public hospital in Brazil. These findings may aid hospitals and manufacturing companies in evaluating the requirements for the use of toric IOLs.

## METHODS

This cross-sectional retrospective study collected data from preoperative keratometry (K) measurements for all consecutive patients who underwent cataract surgery in a public health hospital in Brazil over a two-year period (2014-2015). The exclusion criteria included previous corneal or intraocular surgery and the inability to obtain good quality K measurements. This study was approved by the Human Research Ethics Committee at Bonsucesso Federal Hospital and adhered to the tenets of the Declaration of Helsinki.

A manual keratometer (Bausch and Lomb Inc., Rochester, NY, USA) was used in all cases to measure CA as recommended by Alcon, the manufacturer of the AcrySof toric IOLs[7]. All the measurements were obtained by experienced physicians and before any other eye procedure with the same technique as part of the preoperative biometric assessment for IOL implantation. The mean of three consecutive measurements was recorded for each eye enrolled according to the facility's standard protocol. For this study, CA was classified as with-the-rule if the steep corneal meridian was between 46° and 134° and against-the-rule if the steep corneal meridian was between 0 to 45° and 135° to 180°[2].

JMP statistical software, version 12.0 (SAS Institute, Inc., Cary, NC) was used to perform statistical analyses. The absolute frequencies (n) and relative frequencies (%) were computed for qualitative variables, and the mean and standard deviation (SD) were computed for quantitative variables. The Wilcoxon Rank Sum test was applied to compare quantitative variables. P values less than 0.05 were considered statistically significant.

## RESULTS

A total of 1707 eyes of 1045 patients were enrolled. Figure 1 presents a histogram of the frequency distribution of CA, and table 1 shows the demographic and clinical features of the patients. The mean CA was 0.92 ± (SD) 0.96 D (range 0 - 10.25 D). CA was with-the-rule (steep corneal meridian between 46° and 134°) in 728 eyes (42.6%) and against-the-rule (steep corneal meridian between 0 to 45° and 135° to 180°) in 667 eyes (39.1%).

No significant difference was found between the 860 right eyes and 847 left eyes in flat K (44.02 ± 1.72 D versus 44.08 ± 1.73 D, p=0.43) or steep K (44.93 ±1.72 D versus 45.00 ± 1.76 D, p=0.55) measurements. No statistically significant difference was found between right and left eye CAs (0.92 ± 0.96 D versus 0.92 ± 0.97 D, p=0.68). The flat K (k1) and steep K (k2) values in females were higher than those in males (K1: 44.35 ± 1.70 D versus 43.65 ± 1.67 D, p<0.0001; K2: 45.29 ± 1.72 D versus 44.55 ± 1.67 D, p<0.0001; figures 2 and 3). No statistically significant difference was found between gender regarding CAs (0.93 ± 0.99 D versus 0.89 ± 0.92 D, p0.19).

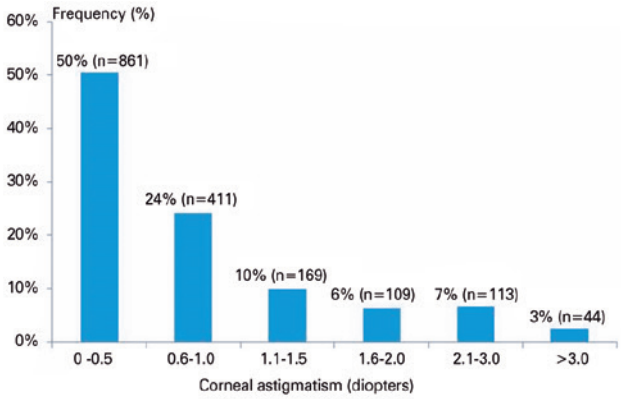


**Figure 1.** Distribution of the corneal astigmatism distribution in all 1707 eyes.

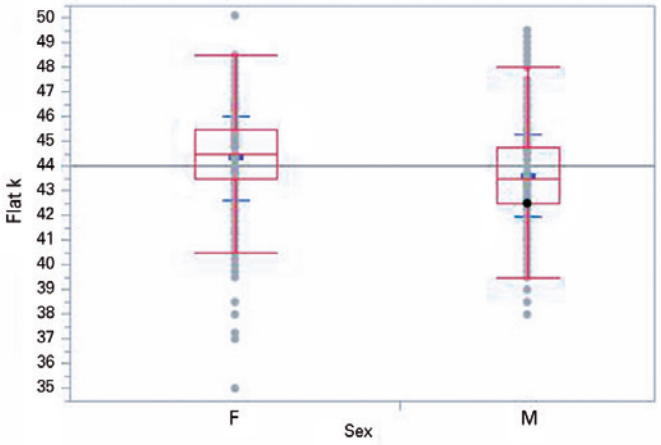


**Figure 2.** Boxplot showing the difference in flat keratometry (K) between males (M) and females (F).

## DISCUSSION

This study showed the frequency of CA in a cataract population in a public hospital in Brazil and established the potential demand for the TIOL. To the best of our knowledge, this is the first study to evaluate the frequency of CA in cataract patients in Brazil. The data highlighted the need for cataract surgeons to consider intraoperative correction of CA.

There are several ways to treat astigmatism at the time of cataract surgery. Some of the techniques used to correct astigmatism during cataract surgery include selective positioning of the phacoemulsification incision, corneal relaxing incisions, limbal relaxing incisions, and TIOL[8]. Every procedure has its own limitations, advantages, and disadvantages[8-10].

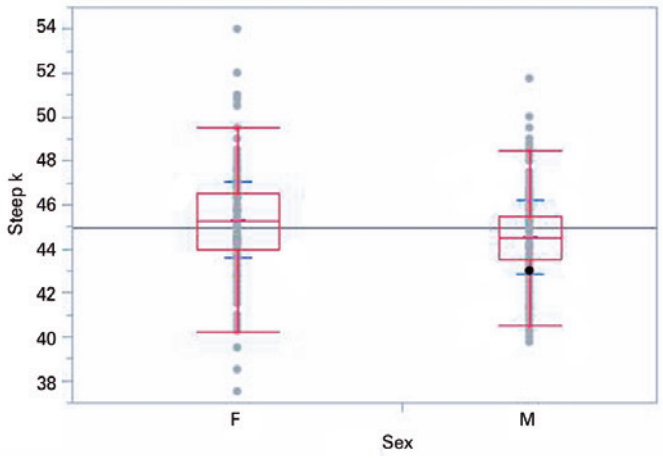


**Figure 3.** Boxplot showing the difference in steep keratometry (K) between males (M) and females (F).

TIOL implantation is considered the most predictable method to correct astigmatism in cataract surgery and can correct preexisting astigmatism as low as -0.25 D. In addition, it is the method of choice for correcting high levels of astigmatism; currently, there are IOL Cylinder Powers up to 6.00 D[9,10].

The frequency of preoperative astigmatism in cataract patients has been reported as 86.6%, of which 35% to 43% of cataract patients have astigmatism ≥1.0 D and 19% to 22% have astigmatism ≥1.5 D[1-5].

Our results showed similarities to values obtained in other populations[1-5]. Despite a slightly higher mean K value in Brazilian patients compared to Europeans, the mean CA was comparable among subjects from different countries[2,3]. Our findings are also consistent with those from a study by Chen et al.[1] in which female patients had steeper corneas than males. Table 1 summarizes the frequency and demographic features found in the present study and in five other studies[1-5].

Half of the eyes presented a CA of 0.50 diopter (or lower), which is roughly equivalent to 0.25 D of spherical

**Table 1.** Comparison of frequency and demographic features between the present study and five other studies

| | Study (First Author) | | | | | |
|---|---|---|---|---|---|---|
| Parameter | Chen[1] | Ferrer-Blasco[2] | Khan[3] | Hoffmann[4] | Lekhanont[5] | Present |
| Country | China | Spain | United Kingdom | Germany | Thailand | Brazil |
| Eyes/patients(n) | 4831/2849 | 4540/2415 | 1230/746 | 23239/15448 | 2010/1005 | 1707/1045 |
| Mean age ± SD | 70.56 ± 9.55 | 60.59 ± 9.87 | 75.54 ± 0.71 | 74 | 68.21 ± 9.19 | 77.13 ± 9.55 |
| Range | 40, 95 | 32, 87 | 30, 110 | - | 42, 96 | 49, 92 |
| Male/female sex (n) | 1090/1759 | 768/1647 | 343/403 | - | 617/388 | 741/966 |
| Mean CA ± SD | 1.01 ± 0.69 | 0.90 ± 0.93 | 1.03 ±0.73 | 0.98 ± 0.78 | 1.05 ± 0.62 | 0.92 ± 0.96 |
| Range | 0.05, 6.59 | 0.25, 6.75 | 0.0, 6.2 | - | 0.0, 4.5 | 0.0, 10.15 |
| Mean keratometry (D) ± SD | | | | | | |
| Flat | 43.76 ± 1.53 | 43.48 ± 1.61 | 43.43 ± 1.49 | - | 44.03 ± 1.56 | 44.05 ± 2.03 |
| Steep | 44.76 ± 1.56 | 44.08 ± 1.59 | 44.46 ± 1.56 | - | 44.91 ± 1.54 | 44.96 ± 2.05 |
| Corneal astigmatism (%) | | | | | | |
| ≤0.5 D | 23.1 | 58.8 | 24.5 | - | 19.7§ | 50.4 |
| ≥1.0 D | 41.3 | 34.8 | 40.4 | 36.0 | 37.8 | 43.1 |
| ≤1.5 D | 81.5 | 83.5 | 79.5 | 84 | - | 84.4 |
| ≥2.0 D | 8.2 | 9.3* | 9.7 | 8.0 | 7.9 | 14.1 |
| ≥2.5 D | 3.5 | 5.6 † | 4.6 | - | - | 8.3 |
| ≥3.0 D | 1.7 | 3.3ᶻ | 1.9 | 2.7 | 1.6 | 4.9 |

CA= corneal astigmatism; §= Not including 0.5 D; *= Not including 2.0 D; †= Not including 2.5 D; Z= Not including 3.0 D.

error and does not significantly degrade vision; instead, it only alters high-contrast visual acuity by approximately one logMAR line, according to previous studies[11,12].

The analysis of our data also revealed that over 40% of the eyes undergoing cataract surgery present 1.00 D or more of CA, and approximately 5% have astigmatism of more than 3.00 D. The conclusions of this study should be applied to the specific population under study and may not be generalized to the entire Brazilian population.

The characteristics of retrospectively collected data limit the analyses but provide enough information for a study of frequency. Despite this limitation, this study is the first report of the frequency of CA in cataract surgery candidates in Brazilian eyes and therefore provides useful data for surgeons, intraocular lens manufacturers and, more importantly, for public health care system administrators.

This study was based on manual K, as has been recommended by TIOL manufacturers when measuring preoperative CA[7]. A study comparing manual K, automatic K, Scheimpflug, and optical biometry (IOL master) revealed that manual K was the most accurate method evaluated, although the other techniques were equally satisfactory in determining CA[7].

The limitations of this study include the absence of posterior CA evaluation. Posterior CA should be valued for more precise CA management because it contributes to the total CA and the anterior surface. Neglecting the posterior cornea usually results in overestimation in WTR (with-the-rule) anterior corneal eyes and underestimation in ATR (against-the-rule) anterior corneal eyes. One study suggested a 9% reduction in the magnitude of the simulated K in eyes with WTR astigmatism and a 16% addition of the magnitude of the simulated K in eyes with ATR astigmatism[13].

In developing countries such as Brazil, where the state provides health service, frequency studies are crucial to enable cost-effectiveness analyses, which may be useful in showing that in the long term, correcting astigmatism at the time of cataract surgery may be more cost-effective than spectacles or contact lenses.

## REFERENCES


1. Chen W, Zuo C, Chen C, Su J, Luo L, Congdon N, et al. Prevalence of corneal astigmatism before cataract surgery in Chinese patients. J Cataract Refract Surg. 2013;39(2):188-92.
2. Ferrer-Blasco T, Montés-Micó R, Peixoto-de-Matos SC, González-Méijome JM, Cerviño A. Prevalence of corneal astigmatism before cataract surgery. J Cataract Refract Surg. 2009;35(1):70-5.
3. Khan MI, Muhtaseb M. Prevalence of corneal astigmatism in patients having routine cataract surgery at a teaching hospital in the United Kingdom. J Cataract Refract Surg. 2011;37(10):1751-5.
4. Hoffmann PC, Hütz WW. Analysis of biometry and prevalence data for corneal astigmatism in 23,239 eyes. J Cataract Refract Surg. 2010;36(9):1479-85.
5. Lekhanont K, Wuthisiri W, Chatchaipun P, Vongthongsri A. Prevalence of corneal astigmatism in cataract surgery candidates in Bangkok, Thailand. J Cataract Refract Surg. 2011;37(3):613-5.
6. Huang J, Maguire MG, Ciner E, Kulp MT, Cyert LA, Quinn GE, et al.; Vision in Preschoolers (VIP) Study Group. Risk factors for astigmatism in the Vision in Preschoolers Study. Optom Vis Sci. 2014;91(5):514-21.
7. Chang M, Kang SY, Kim HM. Which keratometer is most reliable for correcting astigmatism with toric intraocular lenses? Korean J Ophthalmol. 2012 Feb;26(1):10-4.
8. Freitas GO, Boteon JE, Carvalho MJ, Pinto RM. Treatment of astigmatism during phacoemulsification. Arq Bras Oftalmol. 2014;77(1): 40-6.
9. Mozayan E, Lee JK. Update on astigmatism management. Curr Opin Ophthalmol. 2014;25(4):286-90.
10. Kessel L, Andresen J, Tendal B, Erngaard D, Flesner P, Hjortdal J. Toric intraocular lenses in the correction of astigmatism during cataract surgery: a systematic review and meta-analysis. Ophthalmology. 2016;123(2):275-86.
11. Ernest P, Potvin R. Effects of preoperative corneal astigmatism orientation on results with a low-cylinder-power toric intraocular lens. J Cataract Refract Surg. 2011;37(4):727-32.
12. Villegas EA, Alcón E, Artal P. Minimum amount of astigmatism that should be corrected. J Cataract Refract Surg. 2014;40(1):13-9.
13. Jin YY, Zhou Z, Yuan XY, Song H, Tang X. Effect of the posterior corneal surface on total corneal astigmatism in patients with age-related cataract. Int J Ophthalmol. 2018;11(6):958-65.