Relationship between pterygium and biometric error in intraocular lens calculation for cataract surgery

Relação entre pterígio e erro biométrico no cálculo de lentes intraoculares para cirurgia de catarata

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ABSTRACT

Objective: To evaluate the effect of pterygium on different biometric intraocular lens calculation formulas.

Methods: This is an interventionist, prospective, and non-randomized study. We included patients who underwent pterygium surgery and performed a biometric examination before and one month after surgery. We compared the mean variability between these measurements in each intraocular lens formula. We classified the patients according to the TAN staging system and evaluated the effect of pterygium magnitude on biometric variability.

Results: We included 25 eyes (25 patients, 17 women), of which 16 had TAN grade 2 (64%). There was a significant difference between the pre-and postoperative K1 (+0.88D; $p < 0.01$), astigmatism (−0.62D; $p < 0.01$), and axial length (+0.02 mm; $p = 0.03$). All intraocular lens formulas calculated a lower target spheric intraocular lens postoperatively compared to the preoperative calculations, and this variation was correlated with pterygium width. Although Barrett Universal II presented the least variance among the biometric formulas, there was no statistically significant difference between them ($p = 0.172$). Pterygiums larger than 1.85 mm showed at least a 0.5D difference in intraocular lens power calculations.

Conclusion: Pterygium affects biometric calculation, and this effect is correlated with pterygium width. Barrett Universal II is a biometric formula with the smallest change after pterygium surgery, suggesting better results for cataract surgery. Pterygiums larger than 1.85 mm were related to at least 0.5D variation in intraocular lens power calculations. In these cases, we suggest performing pterygium surgery before cataract surgery.

RESUMO

Objetivo: Avaliar o efeito do pterígio em diferentes fórmulas biométricas de cálculo de lente intraocular.

Métodos: Trata-se de um estudo intervencionista, prospectivo e não randomizado. Foram incluídos pacientes submetidos à cirurgia de pterígio e que realizaram exame biométrico antes e 1 mês após a cirurgia. Comparamos a variabilidade média entre essas medidas em cada fórmula da lente intraocular. Classificamos os pacientes de acordo com o sistema de estadiamento TAN e avaliamos o efeito da magnitude do pterígio na variabilidade biométrica.

Resultados: Foram incluídos 25 olhos (25 pacientes, 17 mulheres), dos quais 16 apresentavam TAN grau 2 (64%). Houve diferença significativa entre K1 pré e pós-operatório (+0,88D; $p < 0,01$), astigmatismo (-0,62D; $p < 0,01$) e comprimento axial (+0,02 mm; $p = 0,03$). Todas as fórmulas calcularam uma lente intraocular esférica-alvo inferior no pós-operatório em comparação com os cálculos pré-operatórios, e essa variação foi correlacionada com a largura do pterígio. Embora a *Barrett Universal II* tenha apresentado a menor variância entre as fórmulas biométricas, não houve diferença estatisticamente significativa entre elas ($p = 0,172$). Pterígios maiores que 1,85 mm apresentaram diferença de pelo menos 0,5 D nos cálculos de potência da lente intraocular.

Conclusão: O pterígio afeta o cálculo biométrico, e esse efeito está correlacionado com a largura do pterígio. A *Barrett Universal II* é uma fórmula biométrica com menor alteração após cirurgia de pterígio, sugerindo melhores resultados para cirurgia de catarata. Pterígios maiores que 1,85 mm foram relacionados a pelo menos 0,5 D de variação nos cálculos de potência da lente intraocular. Nesses casos, sugerimos a realização da cirurgia de pterígio antes da cirurgia de catarata.

INTRODUCTION

Pterygium is an abnormal growth of fibrovascular tissue originating from the bulbar conjunctiva that typically appears in the nasal region of the interpalpebral fissure and extends toward the cornea. This condition is frequently associated with senile cataracts in elderly individuals, with age and sun exposure being predisposing factors.[1-3]

Accurate biometric assessment is crucial for cataract surgery. However, when patients have cataracts and pterygium, surgeons must consider how the pterygium might affect the cornea, causing corneal flattening, astigmatism induction, and alterations in biometric assessments. Larger pterygium with greater width tends to induce more astigmatism, and because of flattening, the calculation of intraocular lens (IOL) power may be overestimated.[4-7]

In cases of cataracts and large pterygium, the surgeon should consider performing pterygium excision before cataract surgery because the pterygium can increase astigmatism and overestimate the calculation of IOL power due to corneal flattening. Determining the most accurate IOL formula is essential when we perform combined surgeries. In asymmetric corneas, such as keratoconus, the SRK/T formula is preferred, whereas newer options, such as the Barrett Universal II (UII) and Kane formulas, are promising. However, a consensus should be reached regarding the most accurate formula for pterygium surgery. A previous study suggested using the Holladay 2 formula but did not consider modern IOL formulas.[7-10]

Studies on factors affecting biometric readings in pterygium-affected corneas typically focus on morphometric parameters (horizontal and vertical length and area), disregarding pterygium morphology such as invasion depth, fleshiness, and inflammation. Tan et al. introduced a classification system emphasizing slit-lamp appearance and demonstrated that pterygium with less transparency due to fibrovascular tissue has higher recurrence rates after surgery. This classification system better explains the behavior of pterygium.[11-15]

This study investigated the relationship between pterygium morphological classification and IOL biometric calculation variance. Additionally, we sought to identify the IOL biometric formula with the least variance and correlate it with pterygium characteristics. Finally, we intend to establish a cut-off limit for pterygium width for biometric calculation in cataract surgery without pterygium excision. Our objective was to evaluate the effect of pterygium on different biometric intraocular lens calculation formulas.

METHODS

This study was approved by the Ethics in Health Committee of the Metropolitan University, registered under number CAAE:51922221.3.0000.0082

We conducted an interventionist, prospective, non-randomized study at our Ophthalmologic Department from March through December 2021. We adhered to the Declaration of Helsinki, and all patients provided written informed consent.

We included patients with indications for primary pterygium excision and conjunctival autograft based on the following criteria: symptoms of ocular irritation (e.g., redness, itching, epiphora) despite medical treatment; cosmetic problems; and visual loss (two or more lines on the Snellen chart) that other causes could not explain. We excluded patients older than 80 years old, patients with a history of ocular surgery or trauma, corneal ectasia, and scarring, recurrent pterygium, axial length (AL) smaller than 22.0 mm or larger than 24.5 mm, and AL difference between the two eyes greater than 0.5 mm.

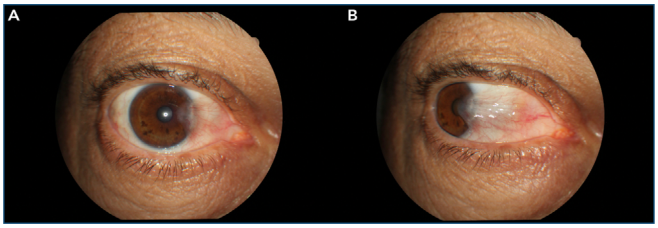
Pre and postoperative assessment

Preoperatively, all patients underwent a complete ophthalmological examination, including visual acuity, refraction, intraocular pressure, fundoscopy, biomicroscopy, keratometry, and biometric measurements. Follow-ups were on the first day, seven days, and 30 days after surgery. Visual acuity, intraocular pressure, and biomicroscopy were assessed at all follow-up visits. At the last follow-up, keratometry and biometric readings were evaluated.

Evaluation of the extension of the pterygium:

We photographed the anterior segment with a CX-1 Retinography camera (Canon Medical System Corporation, New York, USA) in the primary and lateral gaze positions (Figures 1A and 1B). Using the ImageJ program, we evaluated pterygium height (distance between the superior and inferior parts of the head at the limbus) and width (distance from the limbus to the translucid zone).[12]

Pterygium can be classified according to its size (classical grading system) or the visualization of the episcleral vessels (TAN classification, 1997).[11] In classical graduation (NHS - *National Health Service*, *Pterygium Grading System*), the pterygium is divided into grade I (less than 2 mm), grade II (~2-4 mm), and grade III (> 4 mm affecting the visual axis). The TAN classification estimates the



Figures 1. (A and B) Photographs of the anterior segment were taken with a CX-1 Retinography (Canon Medical System Corporation, New York, USA) camera in the primary and lateral gaze positions.

amount of fibrovascular tissue based on the visualization of the episcleral vessels: TAN 1 (total visualization of the episcleral vessels), TAN 2 (partial visualization of the episcleral vessels), and TAN 3 (absence of visualization of the episcleral vessels). Both are useful for inferring the degree of corneal involvement and the risk of pterygium recurrence after a surgical procedure.[11-15]

Keratometry and biometric measures

We used the OA-2000 optical biometer (Tomey, Nagoya, Japan) to evaluate keratometry and biometric measurements. All measurements were performed by the same professional before and 30 days after surgery. We assessed steep (K2), flattest (K1), pterygium-induced astigmatism (defined as the difference between pre- and postoperative keratometry), and IOL calculations (target=0).

We calculated the IOL power with an A-constant of 118.9, using the formulas SRK/T, Hoffer Q, Haigis, Holladay 1, and Barrett UII (aiming for emmetropia). The change in IOL power was defined as the difference between the calculated IOL before and 1 month after surgery.

Surgical technique

Surgeons blinded to the study performed pterygium extraction surgery using the same technique, described as follows. Prime anesthesia was achieved with one drop of tetracaine hydrochloride 1.0% and phenylephrine hydrochloride 0.1%. After proper asepsis, antisepsis, and preparation of the surgical field, the surgeon injected 1 mL of lidocaine hydrochloride + epinephrine (20 mg/mL +0.005 mg/mL), using a 27-G needle, into the subconjunctival space under the pterygium. The head of the pterygium was removed from the cornea with blunt lamina, and the pterygium was dissected using Westcott scissors. Conjunctival grafts were obtained from the superior temporal conjunctiva and attached with drops of fibrin glue (Beriplast® 1.0 mL, CSL Behring GmbH, Marburg, Germany). At the end of the procedure, patients were prescribed a combination of corticosteroid-antibiotic eye drops (moxifloxacin 0.5% + dexamethasone 0.1%) for 4 weeks on regressive treatment.

Statistical analysis

We calculated a sample size of 25 eyes based on the descriptive statistics of a pilot study with five cases and a statistical error (alpha) of 5.0%. Normality was assessed using the Kolmogorov-Smirnov test, and the comparison between pre-and postoperative results was evaluated using the Wilcoxon test for non-normal variables.

Spearman's correlation test assessed the correlation between pterygium variables and biometric/keratometric measurements. We also used the Friedman test to evaluate differences in IOL calculation between formulas and Receiver Operating Characteristic (ROC) curves to establish a cut-off limit for pterygium width that interferes with IOL choice.

Finally, we used the Mann-Whitney test to compare the results between pterygium TAN classes 1,2 3.

RESULTS

This study included 25 eyes from 25 patients (17 females). The mean age was 57.5 +- 19.5 years. The mean width (horizontal length) and height (vertical length) were 1.80 mm (standard deviation – SD = 0.92) and 4.18 mm (SD = 1.43), respectively. Pterygium was classified as NHS grade I (56.7%), 2 (35%), or 3 (8.3%). Sixteen patients had TAN 2 (64%), eight had TAN 1 (32%), and 1 had TAN 3 (4%). Because of the unrepresentative number of pterygium TAN 3, we did not include this group in our statistical analysis.

Table 1 shows the preoperative and postoperative variables, with the mean and standard deviations. Only the pterygium class TAN 2 group showed statistically significant changes in the pre-and postoperative variables. There was a change in mean K1 (+1.10 D; $p < 0.01$), astigmatism (−0.93 D; $p < 0.01$), Barrett UII (−0.60 D; $p = 0.03$), Hoffer Q (−0.78 D; $p < 0.01$), Haigis (−0.78 D; $p = 0.02$), SRK/T (−0.69 d; $p < 0.01$), and Holladay 1 IOL (−0.75 D; $p < 0.01$). In the TAN 1 group, AL was the only significantly different variable in pre and postoperative measurements (+0.06 mm; $p = 0.03$)

All formulas predicted a lower target IOL postoperatively: Barrett UII (−0.48 D; $p = 0.01$), Hoffer Q (−0.62 D; $p < 0.01$), Haigis (−0.58 D; $p = 0.01$), SRK/T (−0.50 D; $p < 0.01$), and Holladay 1 (−0.58 D; $p < 0.01$).

Table 2 shows the results of the Spearman's correlation test. Variations in K1 (pre-and post-surgery, delta) were positively and moderately correlated with pterygium width (r

Table 1. Measurements of pre and postoperative variables, according to the TAN classification

Average		TAN 1 (n=8)		TAN 2 (n=16)		p-value
		SD	Average	SD		
K1	Pre	43.88	1.76	42.06	1.89	0.043
	Post	44.13	2.02	44.16	1.80	0.269
	Delta	0.250	0.732	1.094	1.234	0.109
K2	Pre	44.88	2.17	44.66	2.08	0.83
	Post	44.81	2.25	44.63	2.02	0.854
	Delta	-0.063	0.259	-0.031	0.482	0.801
Astigmatism	Pre	-1.000	0.964	-2.438	1.548	0.013
	Post	-0.688	0.458	-1.469	0.903	0.017
	Delta	0.313	0.678	0.969	1.224	0.174
AL	Pre	23.02	1.10	23.24	0.99	0.54
	Post	23.08	1.05	23.24	0.99	0.603
	Delta	0.054	0.068	0.008	0.035	0.148
Barrett UII	Pre	21.94	2.21	22.41	2.42	0.537
	Post	21.63	1.77	21.81	2.50	0.805
	Delta	-0.313	0.923	-0.594	0.953	0.435
HOFF-Q	Pre	21.81	2.24	22.41	2.64	0.424
	Post	21.44	1.94	21.63	2.72	0.757
	Delta	-0.375	0.744	-0.781	0.930	0.29
Haigis	Pre	23.25	2.54	23.75	23.75	0.498
	Post	23.00	1.81	22.97	2.81	0.902
	Delta	-0.250	1.035	-0.781	1.048	0.204
SRK/T	Pre	21.81	2.12	22.25	2.40	0.622
	Post	21.63	1.90	21.56	2.40	0.951
	Delta	-0.188	0.458	-0.688	0.680	0.071
Holladay 1	Pre	21.81	2.02	22.34	2.56	0.539
	Post	21.50	1.93	21.59	2.60	0.878
	Delta	-0.313	0.704	-0.750	0.837	0.225

SD: standard deviation; Pre: Pre mitomycin; Post: Post mitomycin; Barrett UII: Barrett Universal II

Table 2. Correlation of biometric data and formulas with measurements of length and height of pterygium

		Length		Height	
		Correlation (r)	p-value	Correlation (r)	p-value
K1	Pre	-0.314	0.127	-0.325	0.113
	Post	-0.032	0.878	-0.077	0.714
	Delta	0.583	0.002	0.471	0.017
K2	Pre	0.039	0.852	-0.074	0.724
	Post	0.042	0.844	-0.066	0.754
	Delta	-0.048	0.820	0.006	0.976
Astigmatism	Pre	-0.541	0.005	-0.276	0.181
	Post	-0.275	0.183	0.006	0.978
	Delta	0.509	0.009	0.305	0.138
AL	Pre	-0.025	0.905	-0.045	0.829
	Post	-0.032	0.879	-0.064	0.761
	Delta	-0.033	0.874	-0.033	0.877
Barrett UII	Pre	0.232	0.264	0.244	0.239
	Post	0.047	0.825	0.157	0.452
	Delta	-0.377	0.063	-0.293	0.155
HOFF-Q	Pre	0.264	0.202	0.334	0.103
	Post	0.087	0.680	0.188	0.367
	Delta	-0.393	0.052	-0.331	0.106
Haigis	Pre	0.269	0.193	0.326	0.111
	Post	0.008	0.971	0.130	0.535
	Delta	-0.517	0.008	-0.420	0.037
SRK/T	Pre	0.245	0.238	0.281	0.174
	Post	0.084	0.690	0.182	0.383
	Delta	-0.518	0.008	-0.429	0.033
Holladay 1	Pre	0.256	0.216	0.301	0.143
	Post	0.047	0.824	0.182	0.383
	Delta	-0.514	0.009	-0.362	0.075

SD: standard deviation; Pre: Pre mitomycin; Post: Post mitomycin; Barrett UII: Barrett Universal II.

= 0.583; p <0.01) and height (r = 0.471; p = 0.02). Pterygium width was also positively correlated with pterygium-induced astigmatism (r = 0,509; p-value <0.01) and preoperative astigmatism (r = 0.541; p <0.01). Pterygium width was significantly correlated with changes in biometry calculations using the Holladay, SRK/T, and Haigis formulas. Pterygium height was correlated with changes in biometry using the SRK/T and Haigis formulas. Changes in biometry measured using the Barrett formula were not significantly correlated with pterygium length or height.

Friedman's test did not show a statistically significant difference between IOL formulas (p = 0.172). Because the sample size was small, we compared the formulas (Wilcoxon test) two by two, which did not show significant differences.

We also attempted to identify a cut-off value for pterygium width associated with a larger biometric error. We defined "failure" as a change in biometric calculations bigger than 0.5 D after pterygium surgery and analyzed the curve coordinates that optimize sensitivity with specificity. We observed that the width cut-off value for diagnosing failure was 1.85 for all formulas. Haigis showed the best ROC curve (area under the curve [AUC] = 0.769; p = 0.023), with a sensitivity and specificity of 64.3% and 90.9%, respectively.

DISCUSSION

This study showed that pterygium can significantly impact biometric calculations, and both pterygium length and vascularization are related to changes in biometric calculations after pterygium excision.

Previous studies have shown the effect of pterygium excision on corneal parameters, both in topography and astigmatism induction. Garg et al. found that astigmatism decreased from 3.47 ± 1.74 D to 1.10 ± 0.78 D three months postoperatively.[16] We found a lower change of 0.72 D in astigmatism, probably because we included smaller pterygiums in our sample. Niruthisard et al. studied keratometric and astigmatism stability. They found better stability three months after surgery, and pterygium width exceeding 3.0 mm was associated with a delay in time to corneal astigmatic stability.[2-6,15-22]

We demonstrated that the pterygium could overestimate the target IOL. This has been demonstrated in previous studies with varying amounts of change. In the study by Tang et al., the mean difference was 1.1 D, and 40.74% of the eyes had an overestimation bigger than 1.0 D. Closer to our results, Koc et al. found a mean change that ranged from 0.38 D to 0.59 D, depending on the IOL formula.[7,17,18]

The difference in the study results could be related to pterygium size. The population included in our study had the smallest pterygium, with a height and width of 1.80 (SD 0.92) and 4.18 mm (SD 1.43), respectively. Tang et al. reported a height, width, and area of 2.75 ± 1.06 mm, 4.86 ± 0.94 mm, and 10.86±5.36 mm^2, respectively. Koc et al. did not describe the height but reported a 3.07 ± 0.81 mm width and a mean pterygium area of 6.26 ± 2.07 mm^2. Koc et al. concluded that width and area are correlated with biometric error. Tang et al. found a more relevant impact of width, and we found that height was mostly associated with biometric error.[7,18]

It is inaccurate to compare these three studies and determine the parameter that has the greatest impact on biometry. However, assessing pterygium width in clinical practice is easier and more intuitive than assessing area or height. Therefore, we investigated the effect of width on biometric error. We found that a pterygium with a width greater than 1.85 mm would create a biometric error higher than 0.5 D in all formulas. Koc et al. found a cut-off value of 2.40 mm for width to make a 0.5 D or greater deviation in IOL power calculations, with better results in the Haigis and Holladay 2 formulas. However, he did not study the Barrett formula.[17,18]

Tan et al.[11] demonstrated that pterygium, with less transparency and dense fibrovascular tissue, has higher postoperative recurrence rates. We hypothesized that this classification system could better explain pterygium behavior and its impact on the corneal surfaces. We found that pterygium TAN 1 did not affect keratometric and biometric variables.

We evaluated the change in IOL calculation after pterygium surgery using different biometric formulas, and all of them overestimated the IOL power. This is the first study to include the Barrett IOL formula in the analysis. We found a slight change, with a mean difference of 0.6 D, although without a statistically significant difference compared to the other formulas. SRK/T was the second formula with the least change, whereas the Hoffer Q formula showed the most significant change. The SRK II and Holladay 2 performed better in previous studies, while the Haigis and SKR/T had more change. It is important to note that none of the studies found a statistically significant difference, and all of them excluded patients with extreme AL measurements. In the face of this inconsistency in the results, a larger prospective study will be necessary to determine a more accurate IOL formula for patients with pterygium. Jain et al. studied the same subject and found a refractive surprise in 16.7% of the cases.[14-18]

Joshi et al. compared simultaneous and sequential pterygium and cataract surgery and found that mean K power and IOL power were higher after surgery and found lesser refractive error in the sequential group (0.25 ± 0.5 D in the sequential and -0.50 ± 1.00 D in the simultaneous group, with p=0.04). Although our study aimed to define the best formula in patients with pterygium, in cases where we were not going to perform surgery, we realized that, especially in larger pterygia and TAN 2, it would be more appropriate to perform surgery not simultaneously.[19-25]

Therefore, the presence of pterygium induces significant astigmatism that can be used to predict IOL calculation in cataract surgery. The morphological characteristics of the pterygium have a correlation or tendency with biometric error. In addition, the Barrett UII formula proved comparable to the established formula for corneal ectasias and could be used for pterygium surgery.[8]

One limitation of our study is the short follow-up period. Although some studies have demonstrated corneal stability three months after surgery, a recent study demonstrated stability within one month of surgery. Another prospective observational study demonstrated total corneal power stability within 1 week, corroborating our shorter follow-up. In addition, we failed to include patients with TAN 3 classification, which could show more significant differences in biometry calculation and astigmatism induction and reinforce the hypothesis of a more substantial impact on corneal parameters with denser fibrovascular tissue.[20-22]

Our study demonstrated that pterygium significantly affected IOL calculation in all IOL formulas studied, especially if large and densely vascularized. In conclusion, we suggest that the reader consider all pterygium characteristics and decide for excision before cataract surgery if it is wider than 1.85 mm or class TAN 2. Assuming that the pterygium does not meet these criteria, and that the surgeon plans a simultaneous surgery, we encourage performing different IOL calculation formulas and prioritizing the BARRETT UII results.

CONCLUSION

Pterygium affects biometric calculation, and this effect is correlated with pterygium width. Barrett Universal II is a biometric formula with the smallest change after pterygium surgery, suggesting better results for cataract surgery. Pterygiums larger than 1.85 mm were related to at least 0.5D variation in intraocular lens power calculations. In these cases, we suggest performing pterygium surgery before cataract surgery.

AUTHORS' CONTRIBUTION

Substantial contribution to conception and design: Victor Harasawa Uno, Bianca Nicolela Susanna, Luiz Antonio de Brito Martins.

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Critical revision of the manuscript for important intellectual content: Victor Harasawa Uno, Bernardo Kaplan Moscovici, Bianca Nicolela Susanna, Ítala de Moraes Vieira Gatti, Pablo Felipe Rodrigues, Luiz Antonio de Brito Martins.

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Statistical analysis: Victor Harasawa Uno, Bernardo Kaplan Moscovici, Lucas Cavinato Kwitko.

Administrative, technical, or material support supervision: Ítala de Moraes Vieira Gatti, Luiz Antonio de Brito Martins.

Research group leadership: Luiz Antonio de Brito Martins, Bernardo Kaplan Moscovici.

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