Belin/Ambrósio Enhanced Ectasia Display in cataract surgery and relation to final visual acuity

Belin/Ambrósio Enhanced Ectasia Display na cirurgia de catarata e sua relação com a acuidade visual final

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How to cite:
Stock RA, Berwanger J, Bonamigo EL. Belin/Ambrósio Enhanced Ectasia Display in cataract surgery and relation to final visual acuity. Rev Bras Oftalmol. 2022;81:e0058.

doi:
https://doi.org/10.37039/1982.8551.20220058

Keywords:
Keratoconus; Cataract; Cornea; Corneal diseases; Corneal topography

Descritores:
Ceratocone; Catarata; Córnea; Doenças da córnea; Topografia corneana

Received on:
Apr 16,2022

Accepted on:
July 22, 2022

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Conflict of interest:
no conflict of interest.

Financial support:
the authors received no financial support for this work.

ABSTRACT

Objective: To analyze and describe the coefficients found on maximum Ambrósio Relational Thickness-Maximum (ART-Max) and Belin/Ambrósio Enhanced Ectasia Display total deviation (BAD-D) in eyes with normal corneal topography subjected to cataract surgery with premium intraocular lens implantation and correlated these data with final visual acuity.

Methods: ART-Max and BAD-D data from 103 eyes of patients subjected to implantation of diffractive bifocal intraocular lens, with normal corneal topography who achieved visual acuity of 20/20 or 20/25 without correction after cataract surgery were analyzed. The groups with normal and abnormal values were compared using the chi-square test.

Results: Thirty-two (31.1%) and 71 (68.9%) eyes presented normal and abnormal ART-Max values, respectively. The difference between these groups was significant (p=0.0002). Fifty-five (53.4%) and 48 (46.6%) eyes had normal and abnormal BAD-D, respectively, and intergroup difference was not significant (p=0.9576).

Conclusion: Among patients with normal corneal topography who underwent premium intraocular and had good final visual acuity of 20/20 or 20/25, suspicious or abnormal indices of ART-Max and BAD-D were frequent, providing evidence that it possibly should not be a contraindication.

RESUMO

Objetivo: Analisar e descrever os coeficientes numéricos encontrados nos exames *Ambrósio Relational Thickness-Maximum* (ART-Max) e desvio total do *Belin/Ambrósio Enhanced Ectasia Display* (BAD-D) em olhos com topografia normal submetidos ao implante de lente intraocular *premium* na cirurgia de catarata, correlacionando-os com a acuidade visual final pós-operatória.

Métodos: Foram analisados os resultados de ART-Max e BAD-D de 103 olhos de pacientes submetidos ao implante de lentes bifocais difrativas, que apresentavam exame topográficos normal e alcançaram acuidade visual 20/20 ou 20/25 sem correção visual no pós-operatório final. Para a análise estatística entre os grupos normais e anormais ou suspeitos, utilizou-se o teste do qui-quadrado.

Resultados: Foram encontrados 32 (31,1%) olhos com ART-Max normal e 71 (68,9%) com ART-Max suspeito/anormal. A diferença entre os grupos foi significativa (p=0,0002). Quanto ao BAD-D, foram encontrados 55 (53,4%) olhos com resultados normais e 48 (46,6%) com resultados suspeitos/anormais. A diferença entre os grupos não foi significativa (p=0,9576).

Conclusão: Entre os pacientes com topografia normal submetidos ao implante de lentes *premium* e que alcançaram acuidade visual 20/20 ou 20/25, os índices suspeitos ou anormais de ART-Max e BAD-D eram frequentes, não se configurando em contraindicação para a realização do implante.

INTRODUCTION

With advancements in cataract surgery, the implantation of premium intraocular lenses (IOLs) (toric, bifocal, trifocal, and extended focus) is becoming more common because it reduces the need for glasses. However, the accurate calculation of IOL power is crucial because residual refractive errors result in unsatisfactory surgical outcomes.[1]

Refractive surgery using laser in situ keratomileusis (LASIK) or photorefractive keratomileusis (PRK) may be necessary and is the most common solution in cases involving errors in IOL power calculation and consequent residual refractive errors. However, the development of corneal ectasia postoperatively is one issue, although rare in elderly patients, especially after using LASIK in eyes with suspect corneal topography and tomography.[2] Another available options for this biometric error correction could be IOL piggyback, IOL exchange, and limbal relaxation incision (LRI). Therefore, screening for primary corneal ectasias before cataract surgery is essential for the success of refractive surgeries using LASIK and PRK.[3]

Topographic examinations are useful for diagnosing mild (subclinical) and moderate ectasia; however, slight changes in the posterior surface of the cornea are largely detected.[4] The first signs of keratoconus may occur on the posterior corneal surface even before changes on the anterior surface and are detectable by pachymetry and posterior elevation maps. Thus, tomography is fundamental and indispensable for screening patients with ectatic disease before refractive and cataract surgery. Although some authors have been proposing prior signs of ectasia in corneal epithelium, our article focused on the posterior surface.

To improve ectasia screening, some authors proposed changing the measurement of the reference sphere by excluding the central 3.5mm region of the optical zone centered on the thinnest portion of the cornea from the analysis and keeping the 8mm (best-fit sphere) reference.[5]

The Ambrósio Relational Thickness (ART) evaluates the relationship of the thinnest portion of the cornea with progression indices and shows the Receiver Operating Characteristic (ROC) curve for an average and maximum ART of 0.987 and 0.983, respectively. The best ART-Maximum (ART-Max) cut-off to differentiate normal from keratoconic eyes is 339.[6] Thus, ART-Max values of <339, 339 to 424, and >424 are considered abnormal, borderline, and normal, respectively.

Five parameters are measured in the Belin/Ambrósio Enhanced Ectasia Display (BAD), and the values represent the standard deviation (SD) of the means found in the general population. BAD total deviation (BAD-D) is the average of these parameters and is obtained by regression analysis using a database of normal and keratoconic corneas. BAD-D scores >1.6 are considered as abnormal and are shown in red, whereas scores <1.6 are rated as normal and displayed in green.[7]

Even though tomographic analyses using BAD-D scores improve the diagnosis of ectasia after refractive surgery, the implantation of premium IOLs is contraindicated for patients with suspected corneas because residual refractive errors following cataract surgery may not be corrected with corneal refractive procedures. Still, many patients with abnormal BAD-D but normal corneal topography undergo premium IOL implantation and have good visual outcomes. We considered normal corneal topography when the difference in the curvatures between the eyes is less than 1D, higher curvature is less than 47D, I – S indices are less than 1.4 and there is no suspicion of irregularity image at color map.

This study analyzed BAD-D data in patients with normal corneal topography who underwent cataract surgery and premium IOL implantation and correlated final visual acuity (VA) in patients with better surgical outcomes with ART-Max and BAD-D values.

METHODS

This descriptive retrospective quantitative study analyzed BAD data available in the Pentacam (Oculus, Wetzlar, Germany) and data from posterior corneal elevation maps of patients with normal corneal topography in the Topolyzer (Oculus, Wetzlar, Germany), who underwent cataract surgery with implantation of premium IOLs – Tecnis® Bifocal ZLB (Johnson & Johnson Vision Care, Santa Ana, CA, USA) or Tecnis® Bifocal Toric IOL lenses ZMT (Johnson & Johnson Vision Care, Santa Ana, CA, USA), from January 2017 to October 2019.

To detect changes in ART-Max and BAD-D values in eyes with better outcomes, the patients included in the analysis were divided into two groups with VA 20/20 and 20/25, respectively, without refractive correction. For toric lenses, only patients with lenses centered on the programmed axis were included in the study. Visual acuity was evaluated for at least 90 days after surgery, and BAD data (ART-Max and BAD-D) were correlated with final VA. ART-Max values of <339, 339 to 424, and >424 were considered abnormal, borderline, and normal, respectively. Abnormal and borderline values were rated as abnormal. BAD-D scores >1.6 were considered abnormal, as reported by Valbon et al.[5]

Data were obtained from medical records and stored in the BAD database. BAD-D data were correlated with parameters described in the literature.[5,6]

The inclusion criteria were patients with normal corneal topography who underwent Pentacam examination in the preoperative period (routine procedure in our institution for premium lens implantation) and later underwent cataract surgery with premium IOL implantation. Eyes with unsatisfactory final VA were excluded from the analysis because residual refractive errors in this group were incompatible with VA of 20/25 or higher. Only VA was analyzed rather than patient satisfaction because some patients have no satisfaction after the surgery, even without residual refractive error, normal cornea, and normal macula, but due to the technology itself. The study did not check AV and reading speed closely.

Statistical comparisons between the groups with normal and abnormal ART-Max and BAD-D values and comparisons of VA between the groups were performed using the chi-square test with a 95% confidence interval.

RESULTS

During the study period, cataract surgery with premium IOL implantation was performed in 110 eyes. Seven (6.36%) eyes with VA of less than 20/25 were excluded from the analysis because the residual refractive errors in this group were incompatible with VA of 20/25 or higher.

The cohort included a total of 103 eyes from 63 patients, 44 woman, and 19 men, with a mean age of 75.3 (60 to 87) years. ART-Max data are shown in table 1. A total of 32 eyes had normal ART-Max values, 22 (68.8%) with VA 20/20 and 10 (31,2%) with VA 20/25). A total of 71 (68.9%) eyes had abnormal ART-Max, 54 (76%) with VA 20/20 and 17 (24%) with VA 20/25. The difference between the groups was statistically significant (p=0.0002).

Table 1. *Ambrósio Relational Thickness-Maximum* values and postoperative visual acuity

Final visual acuity n=103	Normal ART-Max n=32 (31.1%)	Abnormal ART-Max n=71 (68.9%)	p-value*
20/20	22 (68.8)	54 (76)	0.0002
20/25	10 (31.2)	17 (24)	

Results expressed as n (%).
*Chi-squared test. For a better understanding of the text, the percentages were calculated for each subgroup.
ART-Max: Ambrósio Relational Thickness-Maximum.

BAD-D data are shown in table 2. A total of 55 eyes had normal BAD-D scores, 41 (74,5%) eyes with VA 20/20 and 14 (25.5%) with VA 20/25. A total of 48 eyes had abnormal BAD-D scores, 36 (75%) with VA 20/20 and 12 (25%) with VA 20/25). The difference between the groups was not significant (p=0576).

Table 2. Belin/Ambrósio Enhanced Ectasia Display (BAD-D) and postoperative visual acuity

Final visual acuity n=103	Normal BAD-D scores n=55 (53.4%)	Abnormal BAD-D scores n=48 (46.6%)	p-value*
20/20	41 (74.5)	36 (75)	0.9576
20/25	14 (25.5)	12 (25)	

Results expressed as n (%).
*Chi-squared test. For a better understanding of the text, the percentages were calculated for each subgroup.
BAD-D: Belin/Ambrósio Enhanced Ectasia Display.

DISCUSSION

Since the development of the anterior corneal topography, new technologies have emerged to improve tomographic and biomechanical measurements and to diagnose high-order aberrations of the optical system. Variables generated by advanced analytical techniques improve the diagnosis and prognosis of keratoconus and other ectatic diseases, surgical planning, and follow-up.[6]

Pentacam corneal tomography, especially outsid the exclusion zone, is useful to evaluate IOL parameters and prevent ectasia.[7] Posterior corneal measurements should be considered for toric IOL calculation and early detection of keratoconus.[8] A study using Pentacam found that the posterior cornea was altered by more than 0.5 D in 12.96% of the eyes of patients who underwent cataract surgery, and this factor affected the measurement of total corneal astigmatism and aberration.[9]

Corneal ectasia is a well-known complication of LASIK, and missed diagnosis before LASIK surgery is a significant risk factor for developing ectatic disease postoperatively. Posterior corneal elevation is an early sign of keratoconus. Therefore, it is essential to measure the posterior corneal curvature and BAD-D in each candidate for LASIK.

The use of laser refractive surgery instead of more complex procedures, such as Piggyback IOL implantation or IOL replacement, given its convenience and efficacy, can effectively correct residual refractive errors.[1]

BAD-D and ART-Max can accurately detect corneal abnormalities before the occurrence of significant topographical changes.[10] BAD-D scores should be interpreted together with clinical history and topographic and biomechanical data.[11] However, patients with posterior corneal elevation and abnormal BAD-D or ART-Max are not good candidates for refractive surgery because refractive correction increases the risk of corneal ectasia.

Eyes with abnormal BAD-D or ART-Max and normal corneal topography were included in this study. However, AV and reading speed were not checked closely. ART-Max values were abnormal in most eyes with normal corneal topography and good VA (20/25 or 20/20), and 3.63% were excluded from the study because they had an abnormal ART-Max and BAD-D with VA below 20/25. A good surgical

outcome regarding VA eliminates the need for refractive correction and underscores the importance of performing topographical examinations before cataract surgery.

Although premium IOL implantation is contraindicated in patients with corneal abnormalities based on BAD-D and ART-Max results, these parameters did not affect final VA, despite the higher number of patients with abnormal values. Therefore, this recommendation was not applicable due to the reduced need for refractive correction in these cases. Our objective was just to show that even with these abnormal values, the result regarding VA were great and, in this population, its more common to have abnormal ART-Max and BAD-D values, so it does not tend to be a contra-indication for IOL premium implantation.

The difference in BAD-D was not significant between the study groups (p=0.9576). Therefore, good final VA was not dependent on BAD-D, supporting the indication of cataract surgery with premium IOL implantation, even in cases in which BAD-D values were abnormal.

CONCLUSION

Patients with normal corneal topography and abnormal ART-Max before cataract surgery and premium intraocular lens implantation had good surgical outcomes and final visual acuity. Despite the higher number of patients with abnormal ART-Max values, both groups achieved a visual acuity of 20/20 and 20/25, eliminating the need for refractive surgery. The percentage of patients with final visual acuity of 20/20 or 20/25 was similar between the groups with high and low BAD-D.

The results showed that normal topography of the anterior cornea, even in the presence of posterior corneal curvature changes assessed by Pentacam, was a good parameter for selecting patients for premium intraocular lens implantation.

Abnormal ART-Max and BAD-D values were common in patients with normal corneal topography who underwent premium intraocular lens implantation and had good final visual acuity, providing evidence that it possibly should not be a contraindication. However, other studies to analyze the quality of vision and satisfaction are necessary.

REFERENCES

1. Abdelghany AA, Alio JL. Surgical options for correction of refractive error following cataract surgery. Eye Vis 2014;1:2.
2. Bhatia K, Shastri A, Mishra D, Satyamurthy KV, Manaktala R, Rati R. Validity of percentage tissue altered as a screening formula for post laser-assisted in-situ keratomileusis ectasia in Indian eyes. Indian J Ophthalmol. 2020;68(12):2995-7.
3. Ambrósio R Jr, Caiado AL, Guerra FP, Louzada R, Sinha RA, Luz A, et al. Novel pachymetric parameters based on corneal tomography for diagnosing keratoconus. J Refract Surg. 2011;27(10):753-8.
4. Patrão LF, Canedo AL, Azevedo JL, Correa R, Ambrósio Jr R. Differentiation of mild keratoconus from corneal warpage according to topographic inferior steepening based on corneal tomography data. Arq. Bras. Oftalmol. 2016;79(4):264-7.
5. Belin MW, Khachikian SS, Ambrósio Jr R, Salomão M. Keratoconus/Ectasia Detection with the Oculus Pentacam: Belin/Ambrósio Enhanced Ectasia Display. Highlights Ophthalmol. 2007;35(6):5-12.
6. Valbon BF, Santos RT, Ramos I, Canedo AL, Nogueira L, Ambrósio Jr R. A Importância da tomografia de córnea para o diagnóstico de ectasia. Rev Bras Oftalmol. 2012;71(5):302-8.
7. Ambrósio R Jr, Luz A, Lopes B, Ramos I, Belin MW. Enhanced ectasia screening: the need for advanced and objective data. J Refract Surg. 2014;30(3):151-2.
8. Preussner PR, Hoffmann P, Wahl J. Impact of posterior corneal surface on toric intraocular lens (IOL) Calculation. Curr Eye Res. 2015;40(8):809-14.
9. Jiang Y, Tang Y, Jing Q, Qian D, Lu Y. Distribution of posterior corneal astigmatism and aberration before cataract surgery in Chinese patients. Eye (Lond). 2018;32(12):1831-8.
10. Kosekahya P, Koc M, Caglayan M, Kiziltoprak H, Tekin K, Atilgan CU. Longitudinal corneal tomographical changes in eyes of patients with unilateral and bilateral non-progressive keratoconus. Cont Lens Anterior Eye. 2019;42(4):434-8.
11. Hanan F, Hussain M, Shah Z, Asrar A, Qureshi S. The Diagnostic accuracy of the Belin/Ambrosio Enhanced Ectasia Total Deviation Display (BAD-D) in screening keratoconus taking tomographic and biomechanical index (TBI) as the gold standard. J Med Sci 2020;28(3):288-91.