ORIGINAL ARTICLE

Relationship of Objective Metrics for Quantifying Age-related Nuclear Cataracts with Visual Acuity and Phacodynamics

Relação de Métricas Objetivas para Quantificar Cataratas Nucleares Relacionadas à Idade com Acuidade Visual e Facodinâmica

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ABSTRACT

INTRODUCTION: An appropriate evaluation cataract degree is essential for deciding to proceed with surgery. Our purpose was to study the relationship between objective metrics for quantifying age-related nuclear cataracts with visual impairment and phacodynamics parameters.

METHODS: Thirty eyes (30 patients) with age-related nuclear cataract were submitted to phacoemulsification. The average lens density (0 to 100) was evaluated by using a rotating Scheimpflug system (Pentacam HR, Oculus, Wetzlar, Germany) and the nuclear opalescence (NO) score was subjectively assessed using the Lens Opacities Classification System III (LOCS III). This different parameters were correlated with preoperative corrected distance vis-ual acuity (CDVA) and cumulative dissipated energy (CDE).

RESULTS: The preoperative CDVA was correlated with the Scheimpflug-measured lens nuclear density value (r=0.617, p<0.01). The CDE was posi-tively correlated with the Scheimpflug-derived average density variable (r=0.681 p<0.01) than with LOCS III NO (r=0.661, p<0.01).

CONCLUSION: The Scheimpflug-measured average density was correlated with subjective lens grading and preoperative CDVA. This metric also pre-sented the highest positive correlation with phacodynamics.

KEYWORDS: Cataract; Lens Nucleus, Crystalline; Diagnostic Techniques, Ophthalmological; Phacoemulsification.

RESUMO

INTRODUÇÃO: Uma avaliação adequada do grau de catarata é essencial para a decisão de prosseguir com a cirurgia. O objetivo foi estudar a relação entre parâmetros objetivos para quantificar cataratas nucleares relacionadas à idade com deficiência visual e parâmetros da facodinâmica.

MÉTODOS: Trinta olhos (30 pacientes) com catarata nuclear relacionada à idade foram submetidos à facoemulsificação. A densidade média da lente (0 a 100) foi avaliada usando um sistema Scheimpflug rotativo (Pentacam HR, Oculus, Wetzlar, Alemanha) e a pontuação de opalescência nuclear (NO) foi avaliada subjetivamente usando o *Lens Opacities Classification System III* (LOCS III). Estes diferentes parâmetros foram correlacionados com a acuid-ade visual corrigida para longe (CDVA) pré-operatória e energia dissipada cumulativa (CDE).

RESULTADOS: O CDVA pré-operatório apresentou uma correlação com o valor de densidade nuclear da lente medido por Scheimpflug (r=0,617, p<0,01). O CDE estava mais positivamente correlacionado com a variável de densidade média derivada de imagem de Scheimpflug (r=0,681 p<0,01) do que com LOCS III NO (r=0,661, p<0,01).

CONCLUSÃO: A densidade média medida derivada da imagem de Scheimpflug foi correlacionada com a classificação subjetiva da lente e CDVA pré-operatório. Este parâmetro também apresentou a maior correlação posi-tiva com a facodinâmica.

PALAVRAS-CHAVE: Catarata; Facoemulsificação; Núcleo do Cristalino; Técnicas de Diagnóstico Oftalmológico.

INTRODUCTION

An appropriate evaluation cataract degree is essential for deciding to proceed with surgery. Objective measurements are fundamental for assessing the outcomes, for determining strategies for improving the results and minimizing intraoperative and postoperative complications. The Lens Opacities Classification System III (LOCS III) is a subjective and cost-effective grading method based on slit-lamp examination.[1,2] Previous studies have shown that the re-producibility issues of this classification are related to interobserver and intra-observer variations.[3]

Scheimpflug imaging provides more precise and reliable lens densitometry measurements compared to the LOCS III grading system.[4-7] Different methods have been described to analyze the cataract density from the Scheimpflug images, and some parameters were found to have a better correlation with cataract staging and visual acuity than others.[8-10] Scheimpflug imaging also allowed the analysis of the relationship between lens densitometry and phacodynamics.[11-15]

The aim of the present study was to investigate the relationship between the different lens evaluation methods, including Scheimpflug-based lens densitometry, and phacodynamics in age-related nuclear cataracts.

METHODS

This retrospective study was conducted on patients who were recruited for a clinical visit in a private clinic from January 2021 to June 2021. The study was approved by the institutional review board and complied with the Declaration of Helsinki of the World Medical Association. No patient had a history of ocular disease, ocular surgery or general disorders affecting vision, such as macular disease, diabetic retinopathy or uveitis. All patients underwent a complete ophthalmic examination, which included corrected distance visual acuity measurement (CDVA; recorded in logMAR units), non-contact tonome-try, slit-lamp biomicroscopy and dilated fundus examination. The nuclear scle-rotic grade was classified according the LOCS III.[2] The same ophthalmologist examined all patients using a slit lamp microscope after pupil dilation with a combination of topical 1.0% tropicamide and 10% phenylephrine. LOCS III nuclear opacity was graded on a scale of 0.1 to 6.9 by comparing a digital photograph of each lens to standard color photographic transparencies of nuclear opalescence (NO). Exclusion criteria were: eyes with poor mydriasis, eyes with any corneal opacities, eyes with a LOCS III nuclear cataract grade greater than 4.1, and eyes with any cortical opacities.

SCHEIMPFLUG SYSTEM MEASUREMENT

The Pentacam HR (Oculus, Wetzlar, Germany) is a Scheimpflug-based device that generates a three-dimensional representation of the anterior seg-ment of the eye. In less than 2 seconds, the rotating camera captures up to 25 slit-images of the anterior segment, collecting 25 000 true elevation data points. For this study, we excluded scans with artifacts that would interfere with the densitometry results, i.e., presence of cortical shadowing artifacts or misplacement of the reference template. The Pentacam Nuclear Staging (PNS) software allows the measurement of objective crystalline lens densi-tometry. The software automatically generates a cylindrical template for the density measurement (Fig. 1). The template volume used for the study had the following features: 4.0 mm diameter, 2.4 mm height, 8.3 mm front curvature, and 4.8 mm back curvature. The three-dimensional template was placed in the center of the nucleus, excluding the anterior and posterior cortex,

Figure 1. Scheimpflug-based lens density of a patient with age-related nuclear cataract.

per-mitting objective quantification of lens opacities inside the template (average density and maximum density parameters) on a continuous scale from 0 to 100 points. For the study purpose, the average density parameter was recorded.

SURGICAL TECHNIQUE

All patients received clear corneal phacoemulsification and posterior chamber intraocular lens implantation by the same surgeon (FFC) under local anesthesia. The stop-and-chop phacoemulsification technique was performed with an INTREPID Balanced Mini Tip (Alcon Laboratories, Inc., Fort Worth, TX, USA) using the Centurion Vision System (Alcon Laboratories, Inc., Fort Worth, TX, USA). At the end of the nucleus management, the cumulative dissipated energy (CDE) parameter was recorded. No intraoperative complications were described.

DATA AND STATISTICAL ANALYSIS

All results were analyzed using MedCalc software (version 14.12.02; Med-Calc, Ostend, Belgium). Values are presented as means ± standard deviations. Data normality was assessed using the Kolmogorov–Smirnov test. Sig-nificant correlations were evaluated using Pearson or Spearman correlation coefficients according to data normality. A *p* value of .05 or less was consid-ered to be statistically significant.

RESULTS

Thirty eyes of 30 patients were included in the study. The study population consisted of 18 females and 12 males. Mean age was 67.34±9.19 years (range 63 – 88) and mean preoperative CDVA was 0.23±0.14 (range 0.0 – 0.5). Table 1 shows the patients' cataract evaluation scores obtained with the different methods.

The average nuclear density was positively correlated with the LOCS III NO score (r=0.63, p<0.01). The preoperative CDVA was correlated with the LOCS III NO score (r=0.558, p<0.01) and with the Scheimpflug-measured lens nuclear density value (r=0.617, p<0.01; Fig. 2).

The mean CDE was 6.09 ± 3.98 (range 0.05– 21.42). Fig. 3 shows the rela-tionships between the CDE and the following cataract evaluation parameters, such as the LOCS III NO score and the Scheimpflug-measured average den-sity. The CDE had stronger relationships with the Scheimpflug-measured lens nuclear density (r=0.681, respectively; both p<0.01) than with LOCS III NO score (r=0.662, p<0.01).

Table 1. Cataract evaluation by the different methods

Parameter	Range	Mean ± SD
LOCS III NO score	1.0 – 4.0	2.50 ± 1.07
Average Density (based on Scheimpflug system)	6.3 – 10.6	7.93 ± 1.03

LOCS III NO: Lens Opacities Classification System III Nuclear Opalescence.

Table 2. Relationships between CDE and LOCS III NO score, average density, and DLI

	Cumulative Dissipated Energy	
Parameter	*r* Value	*p* value
LOCS III NO score	0.646	<.01
Average Density (based on Scheimpflug system)	0.700	<.01
DLI (based on ray-tracing system)	-0.744	<.01

CDE – Cumulative Dissipated Energy; LOCS III NO – Lens Opacities Classification System III Nuclear Opalescence; DLI – Dysfunctional Lens Index.

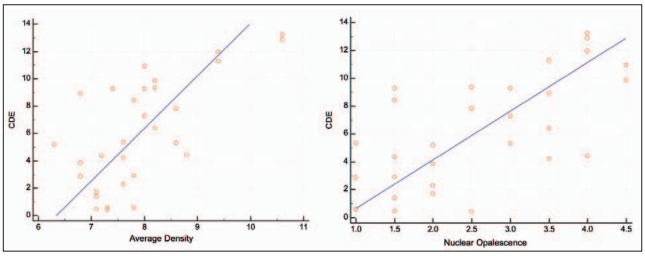

Figure 2. Relationships between (A) CDVA and nuclear opalescence and (B) CDVA and Scheimpflug-measured average density.

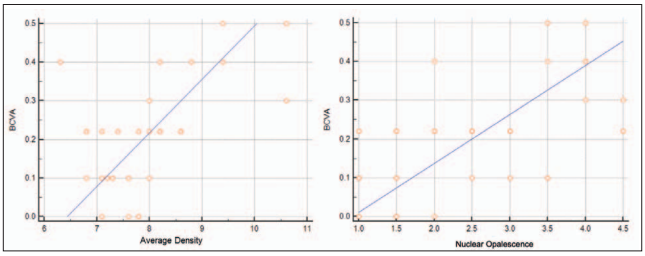

Figure 3. Relationships between (A) CDE and nuclear opalescence and (B) CDE and Scheimpflug-measured average density.

DISCUSSION

The scope of the present study was to assess the relationship of the different cataract evaluation methods with

phacodynamics by using the Centurion Vision System. Our data revealed a positive correlation between the Scheimpflug-derived nuclear density and NO score in eyes with age-related nuclear cataract.[16,17] Both metrics also presented a significant relationship with preoperative CDVA and phacodynamics.

As mentioned in previous studies, the LOCS III classification system presented issues regarding interobserver and intraobserver variability.[3,7] In order to avoid these limitations, Scheimpflug imaging allows objective and repeatable lens densitometry assessments.[9,10] The preoperative CDVA showed a higher correlation with the average density (r=-0.670) than with the LOCS III NO score (r=0.564). Concerning the correlations between these variables and CDVA, previous studies also described similar findings.[16,17] The differences found in the correlation coefficients may be justified by the distinct inclusion criteria, since we enrolled eyes with NO score higher than 3.0 in the LOCS III grading system.

Regarding phacodynamics, the same surgeon (FFC) performed all surgeries in order to guaranty the validity of the study. The CDE parameter is represen-tative of the nucleus hardness, once harder nuclei require more energy during the procedure. In the present study, the CDE also presented a stronger correlation with average density compared to LOCS III NO score.

In a previous report that included surgeries performed by the same surgeon, we found an overlap with the results demonstrated in the present study, especially regarding the correlation coefficients between the CDE and the different methods of cataract assessment.[18] However, the CDE values presented in this study were lower than those reported previously. One reason for this finding might be related to the use of a more recent phacoemulsification device, in which the phacodynamics are more optimized. In this sense, the CDE values recorded in this study are lower compared with previous data. A study should be performed by the same surgeon in order to allow a comparison between different phacoemulsification devices in grade-matched nuclear cataracts. The study also presents other limitations regarding the methodology. The small number of cases and the absence of age-matched controls should be pointed out. There is also no consensus regarding the most representative Scheimpflug-based densitometry method and metric of the lens nucleus. For instance, an inherent limitation of this technology is the presence of reflex artifacts in front of or within the crystalline lens, which may lead to higher and erroneous maximum values.[9,10] "Nucleus color" evaluation was not analyzed in the study, since previous studies have reported that lens density had a stronger correlation with NO.[5,12]

In conclusion, the average density based on Scheimpflug-based lens densitometry was helpful for the objective assessment and phacodynamics prediction in eyes with age-related nuclear cataracts. This metric was also presented a significant relationship with other clinical cataract evaluation methods, such as the NO of the LOCS III grading system.

RESPONSABILIDADES ÉTICAS

Conflitos de Interesse: Os autores declaram a inexistência de conflitos de interesse na realização do presente trabalho.

Fontes de Financiamento: O autor é consultor da Alcon (Fort Worth, Texas, EUA).

Confidencialidade dos Dados: Os autores declaram ter seguido os protocolos da sua instituição acerca da publicação dos dados de doentes.

Proteção de Pessoas e Animais: Os autores declaram que os procedimentos seguidos estavam de acordo com os regulamentos estabelecidos pelos responsáveis da Comissão de Investigação Clínica e Ética e de acordo com a Declaração de Helsínquia revista em 2013 e da Associa-ção Médica Mundial.

Proveniência e Revisão por Pares: Não comissionado; revisão externa por pares.

ETHICAL DISCLOSURES

Conflicts of Interest: The authors have no conflicts of interest to declare.

Financing Support: The author is a consultant for Alcon (Fort Worth, Texas, USA).

Confidentiality of Data: The authors declare that they have followed the protocols of their work center on the publication of data from patients.

Protection of Human and Animal Subjects: The authors declare that the procedures followed were in accordance with the regulations of the relevant clinical research eth-ics committee and with those of the Code of Ethics of the World Medical Association (Declaration of Helsinki as revised in 2013).

Provenance and Peer Review: Not commissioned; externally peer reviewed.

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