The Effect of Photographic Light Exposure on Cup to Disc Ratio Grading

Matthew McSoley

Bascom Palmer Eye Institute, University of Miami Miller School of Medicine

Eldar Rosenfeld

Department of Ophthalmology, Tel Aviv Sourasky Medical Center, Affiliated to the Sackler Faculty of Medicine, Tel Aviv University

Alana Grajewski

Bascom Palmer Eye Institute, University of Miami Miller School of Medicine

Ta Chen Chang (✉ t.chang@med.miami.edu)

Bascom Palmer Eye Institute, University of Miami Miller School of Medicine

Research Article

Keywords: Digital Fundus Photography, Photographic Light Exposure, Glaucoma, Cup-to-disc ratio, Quality Control

Posted Date: July 21st, 2021

DOI: <https://doi.org/10.21203/rs.3.rs-669039/v1>

License: © ⓘ This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Abstract

Background: Digital optic disc images are integral in remote telehealthcare, yet no quality control standards exist for the exposure setting of the images. This study evaluated the relationship between exposure setting and cup/disc ratio (c/d) grading among glaucoma specialists.

Methods: Color disc photos were taken of 50 eyes of pediatric patients under anesthesia at 3 light exposure settings: dark, medium, and bright. 9 glaucoma specialists evaluated the c/d of the imaged discs in random order. The relationships between the exposure levels and the c/d estimates as well as between c/d size and variability were evaluated.

Results: A total of 150 photos of 50 optic discs were graded. The c/d estimates were significantly larger among bright when compared to photos taken at the medium exposure setting (0.53 vs 0.48, $P < 0.001$) as well as the dark exposure setting (0.47, $P < 0.001$). In addition, images with larger mean c/d did not show more variability amongst readers ($P = 0.59$).

Conclusion: Image exposure affects c/d grading of nonstereoscopic disc images. The brighter exposure is associated with larger c/d grading. Exposure consistency is key in longitudinal care.

Background

Digital color fundus photos are integral in remote telehealth ophthalmology care and will play a larger role with the increasing popularity of telehealth.^[1] In particular, digital optic disc images will be central to remote glaucoma screening, evaluation, and management.^[2] Currently, there are no standardized quality control protocols in obtaining digital optic disc images, with the light exposure setting being one of the variables that can change based on the device and the photographer. The effect of this variability on the intra- and inter-grader assessment of the optic disc configurations is unknown.^[3] In this study, we evaluated the effect of light exposure setting on c/d grading of nonstereoscopic disc images among glaucoma specialists with varying levels of experience.

Methods

Digital optic disc images were obtained using the RetCam (Natus Medical, Inc. Pleasanton, CA, USA) from 50 eyes of 50 pediatric patients during examinations under anesthesia. Prior to the exams, informed consent was provided by all parents or legal guardians to have any images obtained used for research and educational purposes. Each optic disc was imaged at 3 different light exposure settings: dark (RetCam light exposure setting 20), medium (exposure setting 25), and bright (exposure setting 30), with the ambient light of the room kept the same for each capture. Only photo triads with clearly visible third-order vessels were kept for the study to ensure sufficiently high resolution. The set of 150 photographs were presented to 9 fellowship-trained glaucoma specialist on high-definition view screens in randomized orders. The 9 glaucoma specialists had practice range between 3 and 42 years (median 6 years). The

glaucoma specialists were asked to provide a c/d estimate to the nearest 0.05. A subset of the photographers were repeatedly graded at random orders to assess intraobserver reliability.

Statistics/Data Analysis

Mean c/d gradings for each of the 3 light settings were compared with each of the others using a paired *t* test. A paired *t*-test was performed in lieu of both Analysis of Variance (ANOVA) and independent samples *t*-test because each of the three comparisons is independently relevant, and the same 50 eyes were used for each of the three light exposure groups. A *P* value of 0.05 or less was considered to be statistically significant.

Results

Across all of the photos evaluated by the 9 glaucoma specialists, the mean c/d ratio was 0.50. The mean c/d (+/- SD) for each of the three groups was 0.47 (0.112) in the dark group (n = 50), 0.48 (0.109) in the medium group (n = 50), and 0.53 (0.118) in the bright group (n = 50).

When the 3 photo groups were compared among each other, the c/d readings were significantly larger among the bright exposure when compared to the medium exposure photos (0.53 vs 0.48, *P* < 0.001) as well as the dark exposure (0.47, *P* < 0.001) (Table 1). In addition, the mean c/d reading at the medium exposure was larger than that of the dark exposure photos, but this difference failed to reach statistical significance (Table 1).

Table 1
– Comparison of cup to disc readings of ophthalmologists across 3 different light exposure settings

Comparisons	Dark (n = 50)	Medium (n = 50)	Bright (n = 50)	P-value
Dark vs. Medium	0.47	0.48		0.3030
Dark vs. Bright	0.47		0.53	< 0.0001*
Medium vs. Bright		0.48	0.53	< 0.0001*

The mean c/d ratios of the nine individual graders ranged from 0.39 to 0.56. No relationship was found between years of training and the variability of the disc readings (*P* = 0.81) (Fig. 1). In addition, images with larger mean c/d did not show more variability amongst readers (*P* = 0.59) (Fig. 2).

Discussion

The results of the study showed that the light exposure setting of digital fundus photos impacted glaucoma specialists' grading of the c/d. Among the same patients at the same time points, graders were more likely to assign a higher c/d if the photo was taken at a bright exposure setting. This has implications for both glaucoma screening and the monitoring of an established patient's disease

progression for both patient care and clinical research purposes. While other factors and sophisticated tools play a role in evaluating glaucomatous damage of an optic nerve, the c/d remains one way to quickly estimate the extent of disease in an individual or the prevalence within a population.^[4, 5]

For established patients, inconsistency in the light exposure setting could lead to the over-calling or the under-calling of a patient's glaucoma progression over time or between different providers that may be using different light exposure settings.

These results also suggest that the outcomes of glaucoma screenings may differ based on the light exposure setting of the fundus camera being used, namely, that a brighter exposure setting would increase the mean c/d of the population being screened, increasing the sensitivity but decreasing the specificity of a screening program. For example, in a retrospective cross-sectional study of Haitian Afro-Caribbean patients screened for glaucoma at community health fairs in Miami, FL, patients were classified as glaucoma suspects if their c/d exceeded 0.7.^[6] Within our sample, 18% of subjects would be classified as glaucoma suspects using the dark exposure setting, and 26% would be considered glaucoma suspects using the bright exposure setting. Although the two study populations differ, this illustrates that light exposure levels could impact prevalence estimates and the success of community glaucoma screenings. Since c/d remains a useful measure for glaucoma detection in community screening programs and retrospective studies, a standard protocol for light exposure setting could improve the accuracy of both.

Conclusions

Exposure consistency is key in both care of the individual patient and study of the population. A standardized exposure setting or an algorithm to adjust exposure setting based on a patient's previous photos would ensure that evaluation of optic discs is reliable and valid across individuals and populations.

Abbreviations

c/d
Cup to disc ratio
SD
standard deviation
ANOVA
Analysis of Variance

Declarations

Ethics approval and consent to participate: The study protocol was approved by the University of Miami Miller of School of Medicine Institutional Review Board/Ethics Committee, adhered to the tenets of the

Declaration of Helsinki and complied with the Health Information Portability and Accountability Act.

Informed consent was obtained for all of the patients in this study to have the images used for research, education, and quality assurance purposes. This report does not contain any of the images or personal information that could lead to the identification of the patients.

Consent for publication: Not applicable.

Availability of data and materials: The data generated and analyzed during this study are available from the corresponding author on reasonable request.

Competing Interests: The authors declare that they have no competing interests

Funding: The project was supported by NIH Center Core Grant P30EY014801, Research to Prevent Blindness Unrestricted Grant, 2021 Glaucoma Research Foundation Shaffer Grant and Grant Number UL1TR002736, Miami Clinical and Translational Science Institute, from the National Center for Advancing Translational Sciences and the National Institute on Minority Health and Health Disparities. Its contents are solely the responsibility of the authors and do not necessarily represent the official views of the NIH.

Authors' contributions: ER, AG, and TC were involved in study design and data collection. MM analyzed and interpreted the study data, and wrote the manuscript. TC was a major contributor in the editing of the manuscript. All authors reviewed and approved the final manuscript.

Acknowledgements: Not applicable

References

1. Sharma M, Jain N, Ranganathan S, et al. Tele-ophthalmology: Need of the hour. Indian J Ophthalmol. 2020;68(7):1328-1338.
2. Chan HH, Ong DN, Kong YX, et al. Glaucomatous optic neuropathy evaluation (GONE) project: the effect of monoscopic versus stereoscopic viewing conditions on optic nerve evaluation. Am J Ophthalmol. 2014 May;157(5):936-44.
3. Foster PJ, Buhrmann R, Quigley HA, et al. The definition and classification of glaucoma in prevalence surveys. Br J Ophthalmol. 2002;86(2):238-242.
4. Myers JS, Fudenberg SJ, Lee D. Evolution of optic nerve photography for glaucoma screening: a review. Clin Exp Ophthalmol. 2018 Mar;46(2):169-176.
5. Waisbourd M, Pruzan NL, Johnson D, et al. The Philadelphia Glaucoma Detection and Treatment Project: Detection Rates and Initial Management. Ophthalmology. 2016;123(8):1667-1674. doi:10.1016/j.ophtha.2016.04.031
6. Bokman CL, Pasquale LR, Parrish RK II, et al. Glaucoma screening in the Haitian Afro-Caribbean population of South Florida. PLoS One. 2014;9(12):e115942.

Figures

Figure 1

Years of ophthalmology experience versus standard deviation of the cup-to-disc readings. No correlation was observed between the cup-to-disc graders' years of experience and the variability of the cup-to-disc readings that they provided for each of the images.

Figure 2

Mean cup-to-disc size versus the standard deviation of the images across all 9 graders. No correlation was observed between the mean cup-to-disc size and the variability of the C/D across the 9 graders. Optic discs graded as larger did not show a decreased in the precision of the grading.