INTRA-EXAMINER AND INTER-EXAMINER VARIABILITY WITH STEREOSCOPIC AND MONOSCOPIC OPTIC NERVE HEAD EVALUATION

by

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ABSTRACT

Background: There is variability in the criteria used by optometrists when measuring cup to disc ratios (C/D) during optic nerve head evaluation. The present "gold-standard" for optic disc assessment is stereoscopic ophthalmoscopy, yet the variety of methods used along with the inherent variability of a subjective assessment makes intra and inter-examiner repeatability a challenging task. This demonstrates the need for a study to determine the repeatability of subjective estimates of C/D ratio. *Methods*: A sample of sixteen photographs, eight stereoscopic and their identical non-stereoscopic (monoscopic) photographs were presented to both students and practicing optometrists for evaluation. A total of 43 participants' responses for each image were used for statistical study in order to compare the intra and inter-examiner repeatability while judging the value of stereoscopic versus monoscopic views. *Results*: For nearly all of the photographs, each group consistently rated the C/D ratio larger when viewed stereoscopically. Inter-examiner variability was found to be consistent using monoscopic and stereoscopic conditions, although the variability with stereopsis was slightly increased. *Conclusion*: Monoscopic and stereoscopic viewing have similar variability when evaluating C/D ratio of digital optic nerve photographs. Also, C/D ratio is larger when viewed with stereopsis.

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Introduction

Careful and consistent evaluation of the optic nerve is vital for the diagnosis, management, and treatment of glaucoma and other optic nerve pathologies. Inconsistency exists in the criteria used by optometrists when measuring cup to disc (C/D) ratios during optic nerve head evaluation. The present "gold-standard" for C/D evaluation is stereoscopic ophthalmoscopy, yet the variety of methods used along with the inherent variability of a subjective assessment makes intra and inter-examiner repeatability a challenging task. Differences in evaluation of C/D ratio have been noted anecdotally, especially by students of optometry. This demonstrates the need for a study to determine the repeatability of subjective estimates of C/D ratio.

Previous studies were able to estimate the inter-examiner variability using 2-dimensional (monoscopic) images. Newer technology allows for 3-dimensional (stereoscopic) photography. This provides the ability to manipulate real life situations and should offer a better estimation of inter-examiner variability, and improve intra-examiner consistency.

This study will attempt to demonstrate the amount of variability when determining C/D ratio while viewing monoscopic and stereoscopic photographs. Low variability will support the continued use of stereo photography to track patients' optic nerve status over time, which may be beneficial with electronic medical records. High variability might suggest developing more stringent evaluation procedures or increasing reliance on automated instruments.

Methods

Participants: Participants were optometrists or students currently enrolled in the 2nd, 3rd, or 4th year of optometry school at the Michigan College of Optometry.

Task: The participants were asked to evaluate the C/D ratio of 16 optic nerve photographs as viewed on a 17-inch flat panel computer monitor. C/D ratios were recorded in horizontal over vertical notation on the provided survey (Appendix A). The photographs were numbered 1 through 16 and placed in a random order. The first eight photographs were a single image taken from the same stereopair used in the following eight photographs.

The photographs were taken using a Canon 12 mega-pixel non-mydriatic digital fundus camera. The stereoscopic photographs were made using Synamed software and viewed through a stereoscopic viewing device produced by Berezin Stereo Photography Products.

Calculations: The participants were arranged into five groups for statistical analysis: Total Participants, Optometrists, Forth Year, Third Year, and Second Year Students of Optometry. Also, the difference between each monoscopic photograph calculations and its matching stereoscopic photograph calculations were presented side by side for comparison.

Results

Grouping of Participants: 43 people participated in the study: 17 optometrists, 2 fourth year students of optometry, 14 third year students, and 10 second year students. There were 21 male and 22 female participants. Participants were grouped into five categories: Total Participants, Optometrists, Forth Year, Third Year, and Second Year Students of Optometry.

Calculations: For each group, the following calculations were performed for every photograph: mean, median, mode, range, and standard deviation (SD). These calculations are presented in the tables below. The monoscopic photo (m) is listed first, followed by its matching stereoscopic photo (s).

Table 1a. Total Surveyed: Calculations of Cup to Disc Ratio

Photo	1m	14s	2m	16s	3m	10s	4m	11s
Mean	.34/.32	.34/.35	.53/.5	.66/.66	.68/.71	.76/.78	.33/.34	.31/.28
Median	.3/.3	.32/.3	.5/.5	.65/.7	.7/.7	.8/.8	.3/.3	.3/.3
Mode	.3/.3,.4	.3/.4	.5/.5	.6/.7	.7/.8	.8/.8	.3/.3	.3/.3
Range	.1-.8/.1-.8	.1-.6/.1-.7	.35-.7/.35-.7	.5-.9/.4-.95	.4-.85/.4-.85	.4-.9/.4-.9	.1-.8/.1-.9	.1-.6/.1-.6
SD	.15/.16	.13/.15	.09/.09	.10/.12	.1/.1	.1/.1	.13/.14	.12/.11

Table 1b. Total Surveyed: Calculations of Cup to Disc Ratio

Photo	5m	9s	6m	15s	7m	12s	8m	13s
Mean	.42/.48	.5/.53	.63/.66	.76/.77	.46/.50	.56/.6	.33/.33	.38/.38
Median	.4/.5	.5/.5	.65/.7	.8/.8	.5/.5	.55/.6	.3/.3	.4/.3
Mode	.5/.5	.5/.6	.7/.7	.8/.8	.4/.4	.6/.6	.3/.3	.3/.3
Range	.25-.6/.3-.7	.3-.75/.3-.8	.4-.8/.4-.8	.5-.9/.5-.9	.2-.7/.2-.7	.4-.8/.4-.85	.2-.55/.2-.55	.2-.6/.2-.7
SD	.11/.1	.11/.13	.09/.09	.09/.09	.12/.12	.11/.09	.08/.08	.12/.13

Table 2a. Optometrists: Calculations of Cup to Disc Ratio

Photo	1m	14s	2m	16s	3m	10s	4m	11s
Mean	.4/.39	.39/.36	.53/.5	.67/.69	.68/.73	.77/.8	.38/.37	.36/.32
Median	.4/.4	.35/.35	.5/.5	.65/.7	.7/.75	.8/.8	.4/.35	.3/.3
Mode	.3/.4	.35/.35	.5/.5	.7/.7	.7/.7,.8	.7,.8/.8	.3/.3	.3/.3
Range	.3-.6/.2-.65	.2-.6/.2-.6	.35-.7/.35-.7	.5-.9/.4-.95	.4-.6/.4-.7	.6-.9/.6-.9	.2-.5/.25-.6	.2-.6/.15-.6
SD	.1/.13	.11/.11	.09/.09	.09/.11	.09/.07	.08/.08	.09/.09	.10/.11

Table 2b. Optometrists: Calculations of Cup to Disc Ratio

Photo	5m	9s	6m	15s	7m	12s	8m	13s
Mean	.46/.53	.51/.57	.67/.7	.79/.8	.52/.56	.56/.62	.35/.36	.41/.42
Median	.5/.5	.5/.6	.7/.7	.8/.8	.5/.6	.6/.6	.35/.35	.4/.4
Mode	.4,.5/.5	.5/.6	.7/.7	.8/.8	.5/.6	.6/.6	.4/.3	.5/.3,.5
Range	.25-.6/.3-.7	.4-.75/.4-.75	.6-.8/.6-.8	.6-.9/.7-.9	.3-.7/.35-.7	.4-.75/.45-.85	.2-.55/.2-.55	.2-.6/.2-.7
SD	.11/.11	.09/.11	.06/.05	.08/.05	.1/.1	.10/.09	.09/.09	.14/.15

Table 3a. Forth Year Students of Optometry: Calculations of Cup to Disc Ratio

Photo	1m	14s	2m	16s	3m	10s	4m	11s
Mean	.3/.33	.4/.4	.6/.6	.73/.7	.83/.8	.8/.83	.35/.4	.2/.18
Median	.3/.32	.4/.4	.6/.6	.73/.7	.83/.8	.8/.83	.35/.4	.2/.18
Mode	.3/.3,.35	.35,.45/.35,.45	.5,.7/.5,.7	.7,.75/.7	.8,.85/.8	.8/.8,.85	.3,.4/.3,.5	.1,.3/.15,.2
Range	.3/.3-.35	.35-.45/.35-.45	.5-.7/.5-.7	.7-.75/.7	.8-.85/.8	.8/.8-.85	.3-.4/.3-.5	.1-.3/.15-.2
SD	0/.04	.07/.07	.14/.04	.04/0	.04/0	0/.04	.07/.14	.14/.04

Table 3b. Forth Year Students of Optometry: Calculations of Cup to Disc Ratio

Photo	5m	9s	6m	15s	7m	12s	8m	13s
Mean	.45/.48	.53/.48	.63/.63	.83/.83	.45/.45	.65/.68	.33/.33	.4/.4
Median	.45/.48	.53/.48	.63/.63	.83/.83	.45/.45	.65/.68	.33/.33	.4/.4
Mode	.4,.5/.4,.5	.35,.7/.3/.65	.6,.65/.6,.65	.8,.85/.8,.85	.45/.4,.5	.6,.7/.65,.7	.3,.35/.3,.35	.4/.4
Range	.4-.5/.4-.55	.35-.7/.3-.65	.6-.65/.6-.65	.8-.85/.8-.85	.45/.4-.5	.6-.7/.65-.7	.3-.35/.3-.35	.4/.4
SD	.07-.11	.25/.25	.04/.04	.04/.04	0/.07	.07/.04	.04/.04	0/0

Table 4a. Third Year Students of Optometry: Calculations of Cup to Disc Ratio

Photo	1m	14s	2m	16s	3m	10s	4m	11s
Mean	.35/.31	.32/.35	.51/.49	.63/.64	.70/.72	.79/.82	.26/.28	.31/.28
Median	.3/.3	.3/.35	.5/.5	.6/.6	.7/.75	.8/.8	.25/.25	.3/.3
Mode	.3/.3,.4	.0,.3/.2,.4	.5/.5	.6/.6	.8/.8	.8/.8,.9	.2,.4/.3,.4	.3,.4/.3
Range	.1-.8/.1-.8	.1-.6/.1-.65	.35-.7/.35-.6	.5-.9/.4-.9	.5-.8/.5-.85	.6-.9/.6-.9	.1-.4/.1-.6	.1-.5/.1-.4
SD	.18/.18	.14/.17	.11/.09	.1/.12	.097/.103	.1/.095	.12/.15	.12/.089

Table 4b. Third Year Students of Optometry: Cup to Disc Ratio

Photo	5m	9s	6m	15s	7m	12s	8m	13s
Mean	.39/.44	.51/.52	.64/.66	.76/.79	.43/.49	.55/.58	.31/.31	.37/.4
Median	.4/.4	.5/.5	.7/.7	.8/.8	.4/.5	.5/.6	.3/.3	.3/.3
Mode	.3/.4	.4,.5/.5	.7/.7	.8/.8	.4/.5	.5/.6	.3/.3	.3/.3
Range	.3-.5/.3-.5	.3-.7/.2-.7	.4-.8/.5-.8	.5-.9/.5-.9	.2-.6/.3-.7	.4-.7/.4-.7	.2-.4/.2-.4	.2-.6/.2-.7
SD	.09/.08	.13/.15	.11/.09	.100/.0997	.13/.1	.13/.09	.07/.07	.12/.162

Table 5a. Second Year Students of Optometry: Calculations of Cup to Disc Ratio

Photo	1m	14s	2m	16s	3m	10s	4m	11s
Mean	.23/.2	.28/.3	.56/.5	.68/.62	.62/.62	.7/.71	.34/.38	.26/.22
Median	.2/.1	.2/.3	.6/.5	.65/.6	.6/.6	.7/.7	.3/.3	.2/.2
Mode	.1/.1,.2,.3	.2/.3	.6/.5	.6,.8/.6,.7	.6/.6	.8/.7,.8	.3/.3	.2/.2
Range	.1-.4/.1-.3	.1-.5/.1-.7	.4-.7/.4-.7	.5-.8/.4-.8	.4-.8/.4-.8	.4-.8/.4-.8	.2-.8/.2-.9	.1-.5/.1-.4
SD	.12/.09	.16/.19	.09/.1	.11/.12	.11/.11	.13/.13	.18/.22	.13/.1

Table 5b. Second Year Students of Optometry: Calculations of Cup to Disc Ratio

Photo	5m	9s	6m	15s	7m	12s	8m	13s
Mean	.41/.46	.46/.47	.56/.6	.67/.68	.42/.43	.54/.67	.3/.3	.34/.31
Median	.4/.5	.5/.5	.5/.6	.7/.7	.4/.4	.5/.6	.3/.3	.4/.3
Mode	.5/.5	.5/.4,.5	.5/.6	.7/.7	.4/.4	.5/.6	.3/.3	.4/.3
Range	.2-.6/.3-.6	.3-.6/.3-.6	.4-.7/.4-.7	.5-.8/.5-.8	.2-.6/.2-.7	.4-.7/.4-.7	.2-.4/.2-.4	.2-.4/.2-.4
SD	.13/.09	.09/.1	.1/.1	.09/.1	.13/.15	.11/.09	.05/.05	.07/.06

Discussion

Stereoscopic methods of photographic C/D assessment are considered to be better than monoscopic methods.[1] A study by Rumsey et al. demonstrated the importance of stereopsis while evaluating C/D ratios, finding that stereoscopic conditions yield less variability and increases the examiner's sensitivity.[2] Even though stereoscopic photography mimics clinical evaluation, there is an inherent subjectivity of measurements, which contributes to inter-examiner variability. It is important to have consistent and reliable information for proper diagnosis and management of glaucoma and other optic nerve pathologies.

Photo-documentation is frequently used and enables clinicians to accurately quantify progression of optic nerve pathologies. Until recently, the photo-documentation of choice was slide photographs or monoscopic computer images. A study by Jamara et al. evaluated the quality of these stereoscopic computer images as a method of photo-documentation, and found them to be a reliable practical application.[3] Using these stereoscopic images to study inter-examiner variability, as well as the consistency of an individual observer, it should be expected then to yield the same decrease in variability as real life stereoscopic ophthalmoscopy.

This study compared digital stereoscopic and monoscopic optic nerve assessment to determine inter-examiner and intra-examiner variability. After analysis of the results, inter-examiner variability was found to be consistent using monoscopic and stereoscopic conditions, although the variability with stereopsis was slightly increased (see Table 7).

This agrees with a study by Parkin et al, which indicates that monoscopic viewing is nearly as effective as stereoscopic viewing.[4] These results are contrary to our prediction that stereoscopic photographs would yield less variability. Interestingly, for nearly all photographs, individual participants consistently rated the C/D ratio larger when viewed stereoscopically. This demonstrated consistent intra-observer analysis.

When each group was compared for consistency of evaluation, inter-observer agreement was found to be higher for experienced clinicians than for students of optometry. However, the range of standard deviations for the groups is similar (see Table 6). It is also similar when comparing stereoscopic and monoscopic images (see Table 7). These finding are consistent with a study by Hyranchak et al, in which C/D ratio assessment varies with experience of the clinician.[5]

Table 6. Comparison of the mean of the standard deviations for each group

Group	Mean of Std Deviations
Total	0.11094
OD	0.09563
4th	0.06156
3rd	0.11518
2nd	0.1125

Table 7. Comparison of the mean of the standard deviation for monoscopic and stereoscopic evaluations for each group

Group	Monoscopic	Stereoscopic
Total	0.10938	0.1125
OD	0.0925	0.1
4th	0.055	0.06813
3rd	0.11063	0.11973
2nd	0.11375	0.11125

This study had several limitations for determining clinical significance of using stereo photography. Participants may not have had previous exposure to stereoscopic images, and two participants stated that stereopsis was not achievable. Another limitation was the small sample size of each group. Also, this study only used participants in affiliation with the Michigan College of Optometry. A larger sampling from a greater population could increase the significance of this study.

Conclusion

This study demonstrated three significant findings. First, monoscopic and stereoscopic viewing have similar variability when evaluating C/D ratio of optic nerve photographs. Second, C/D ratio is larger when viewed with stereopsis. Finally, optometrists yielded higher inter-observer agreement than students of optometry.

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Appendix A

Survey of Optic Nerve Evaluation

Please answer the following background information:

Are you an optometry student? Y N

If yes, what year are you currently in? 1 2 3 4

If no, what year did you graduate? _____

Do you have normal stereopsis? Y N

Clinically, are you able to achieve stereo views while evaluating optic nerves? Y N

From the photo survey, please record your answers below:

Photo 1: H:_____ V:_____

Photo 2: H:_____ V:_____

Photo 3: H:_____ V:_____

Photo 4: H:_____ V:_____

Photo 5: H:_____ V:_____

Photo 6: H:_____ V:_____

Photo 7: H:_____ V:_____

Photo 8: H:_____ V:_____

Photo 9: H:_____ V:_____ Are you able to achieve stereo view? Y N

Photo 10: H:_____ V:_____ Are you able to achieve stereo view? Y N

Photo 11: H:_____ V:_____ Are you able to achieve stereo view? Y N

Photo 12: H:_____ V:_____ Are you able to achieve stereo view? Y N

Photo 13: H:_____ V:_____ Are you able to achieve stereo view? Y N

Photo 14: H:_____ V:_____ Are you able to achieve stereo view? Y N

Photo 15: H:_____ V:_____ Are you able to achieve stereo view? Y N

Photo 16: H:_____ V:_____ Are you able to achieve stereo view? Y N