

ORIGINAL ARTICLE

Reliability of Halo & Glare Simulator in Characterise Types of Halo and Glare

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ABSTRACT

Introduction: To evaluate the reliability of glaremeter in quantifying glare and halo using simulation. **Material and Methods:** One hundred and twenty young adults were recruited in this prospective study. A comprehensive optometric examination was done prior to photic phenomena test (PPT). Room luminance were set in a dim room with a standardised luminance of 85 cd/m². Participant were asked to adjust the intensity and size of halo, glare and starburst using the simulator built-in scale. The PPT findings were classified into four groups; none, mild, moderate and severe. For inter-rater reliabilities, two examiners evaluate the same participant within a week. Bland–Altman plots and intraclass correlation coefficients (ICCs) were used to describe reliability of measurement. **Results:** For the first visit, mean and standard deviation (mean $\pm$ SD) of halo size and intensity were 27.20 ± 6.54 and 28.13 ± 22.93 respectively. For glare size and intensity, mean $\pm$ SD were 23.80 ± 13.80 and 38.42 ± 20.24 respectively. For the second visit, the mean $\pm$ SD halo size and intensity were 24.97 ± 21.79 and 26.75 ± 22.04 respectively. For glare size and intensity, mean $\pm$ SD were 22.47 ± 15.46 and 38.07 ± 18.53 respectively. Paired T-test findings revealed no significant difference between all parameters, between both visits (All $P > 0.05$). ICCs revealed good correlations for all parameters (all r -value > 0.75). Bland Altman plot showed agreement of measurements for all parameters were within the 95% confidence interval. **Conclusion:** Halo & Glare simulator is reliable to quantify photic phenomena. *Malaysian Journal of Medicine and Health Sciences* (2025) 21(6): 1-7. doi:10.47836/mjmhs.v21.i6.1393

Keywords: Glare, Halo, Reliability, Photic phenomena test, Visual disturbance

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INTRODUCTION

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mild, moderate and severe. For inter-rater reliabilities, two examiners evaluate the same participant within a week. Bland–Altman plots and intraclass correlation coefficients (ICCs) were used to describe reliability of measurement. **Results:** For the first visit, mean and standard deviation (mean $\pm$ SD) of halo size and intensity were 27.20 ± 6.54 and 28.13 ± 22.93 respectively. For glare size and intensity, mean $\pm$ SD were 23.80 ± 13.80 and 38.42 ± 20.24 respectively. For the second visit, the mean $\pm$ SD halo size and intensity were 24.97 ± 21.79 and 26.75 ± 22.04 respectively. For glare size and intensity, mean $\pm$ SD were 22.47 ± 15.46 and 38.07 ± 18.53 respectively. Paired T-test findings revealed no significant difference between all parameters, between both visits (All $P > 0.05$). ICCs revealed good correlations for all parameters (all r -value > 0.75). Bland Altman plot showed agreement of measurements for all parameters

were within the 95% confidence interval. Conclusion: Halo & Glare simulator is reliable to quantify photic phenomena

MATERIALS AND METHODS

Study design

This prospective cross-sectional study recruited 120 young adults, and was conducted from March to June 2023. The study protocols were approved by the International Islamic University Malaysia (IIUM) Research Ethics Committee (IREC 2019-125) and comfort with the tenets of the Declaration of Helsinki. Prior to data acquisition, written consent was obtained. Inclusion criteria includes aged 20 - 40 years, best-corrected visual acuity (BCVA) of 6/6 or better (10), non-contact lens wearer (11) and normal contrast sensitivity function (CSF)(12). Patients with a history of ocular trauma, evidence of active ocular infection in either eye, or significant underlying ocular pathology affecting the ocular surface or the anterior eye were excluded (13-16). All participants undergo a comprehensive optometric examination including slit-lamp biomicroscopy prior to recruitment (17,18). Contrast sensitivity function (CSF) and VA were measured using M&S Technologies Smart System II (SSII, Park Ridge, IL, USA). The room luminance were measured using the M&S Smart System II (MSSS-II; M&S Technologies Inc, Niles, IL, US) in a dim room with a standardised luminance of 85 cd/m² as suggested by the manufacturer guideline (43) and previous works (12).

Halo & Glare Simulator (Carl Zeiss Meditec AG, Germany)

Halo & Glare Simulator (Carl Zeiss Meditec AG, Germany) (Fig. 1), a computer-based simulator software developed by Kretz et al. (44) was used to objectively measure halo, glare and starburst. Each participant were shown a visual representation of photic phenomena (halo, glare and starburst) around the light source. The halo size is defined as the diameter of the whole halo while the halo ring width is defined as the breadth of each halo ring. In conducting the PPT, each participants were sat in a room and the illumination were reduced to simulate mesopic condition. The distance between participant and the light source were sat at 50 cm. Then, while reproducing the photic phenomena, participant able to alter the size and intensity of halos and glare independently around the light sources on a sliding scale from 0 (nil) to 100 (maximum) with the aim of creating an image on screen that best represents their experience of halos/glare (19). Subsequently, the same procedure was repeated for starburst. The brightness of visual display unit used for the simulator was set at 50%. The specification of visual display unit (VDU) used was a Samsung 13-inch liquid crystal display (LCD) monitor with a resolution of 2160 x 1440 pixels (Samsung Corp, Seoul, South Korea). This scale was set in both visual and analogue, allowing participants to adjust the

built-in slide bar to represent their perception of photic phenomena around light sources to imitate simulation of night driving (20). The findings were classified into four groups; none (0 - 25%), mild (25% - 50%), moderate (50% - 75%) and severe (75% - 100%)(Fig. 2). All parameters were recorded accordingly.



Fig 1 : computer-based Halo & Glare Simulator (Carl Zeiss Meditec AG, Germany).

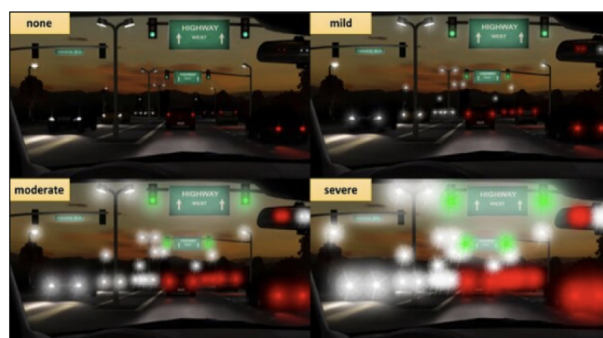


Fig 2 : Halo and Glare classification

Statistical analysis

To evaluate repeatability and reproducibility of the PPT, this study employed two examiners evaluate the same participant on within a week to assess the inter-rater reproducibility and reliability. Bland–Altman plots were used for the analysis of reproducibility while the intra-grader and inter-grader reliability were assessed using intraclass correlation coefficients (ICCs). Statistical analyses were performed using IBM SPSS (Predictive analytics software) (version 20, SPSS Inc., Chicago, IL, USA). Prior to data analysis, the normality of all data was tested using ratio of skewness and kurtosis with ± 2.50 were taken as normally distributed (16). P-value of 0.05 was set as level of significance.

RESULTS

This study included 120 young adults (mean age: 26.30 ± 6.54 years). For comparison distribution of photic phenomena, halo were divided into three types; Type 1 (diffuse halo ring), Type 2 (starburst)

and Type 3 (distinct halo ring). While for glare, it was divided into two types; Type 1 (concentric glare) and Type 2 (eccentric ring). During the first visit, 84 (70%) participants reported seeing starburst (Type 2), while 16 (13.3%) reported diffuse halo ring (Type 1), 10 (8.4%) reported seeing distinct halo ring (Type 3) and 10 (8.3%) participants reported not seeing any halo. For glare, 81 (67.5%) participants reported seeing concentric glare (Type 1) and 24 (20%) participants reported seeing eccentric glare (Type 2) and 15 (12.5%) participants reported not seeing any glare. For the second visit, 86 (71.7%) participants reported seeing starburst (Type 2), while 14 (11.7%) reported diffuse halo ring (Type 1), 10 (8.3%) reported seeing distinct halo ring (Type 3) and 10 (8.3%) participants reported not seeing any halo. For glare, 83 (69.2%) participants reported seeing concentric glare (Type 1) and 22 (18.3%) participants reported seeing eccentric glare (Type 2) and 15 (12.5%) participants reported not seeing any glare. Paired T-test findings revealed no significant difference between all parameters (All $P > 0.05$). The descriptive findings were summarised in Table I.

Table I: Distribution of photic phenomena measured between two visits (n = 120)

Type	Visit 1	Visit 2	P-value*
Halo, n (%)			
Type 1 (diffuse halo ring)	16 (13.3)	14 (11.7)	0.757
Type 2 (starburst type)	84 (70.0)	86 (71.7)	0.865
Type 3 (distinct halo ring)	10 (8.4)	10 (8.3)	0.995
No halo reported	10 (8.3)	10 (8.3)	0.996
Glare, n (%)			
Type 1 (Concentric glare)	81 (67.5)	83 (69.2)	0.786
Type 2 (eccentric ring)	24 (20.0)	22 (18.3)	0.875
No glare reported	15 (12.5)	15 (12.5)	0.992

*Paired T-test with 0.05 was set as level of significance.

For reliability testing of PPT, in the first visit, the mean and standard deviation (mean $\pm$ SD) of halo size and intensity were 27.20 ± 6.54 and 28.13 ± 22.93 respectively. Meanwhile for glare size and intensity, the mean $\pm$ SD were 23.80 ± 13.80 and 38.42 ± 20.24 respectively. For the second visit, the mean and standard deviation (mean $\pm$ SD) halo size and intensity were 24.97 ± 21.79 and 26.75 ± 22.04 respectively. Whereas for glare size and intensity, the mean $\pm$ SD were 22.47 ± 15.46 and 38.07 ± 18.53 respectively. Paired T-test findings revealed no significant difference between all parameters (All $P > 0.05$). The ICCs between the inter-rater and inter-participant reliability and the measured PPT values showed high reliability for all parameters. The reliability testing findings were summarised in Table II.

Table II: Descriptive findings for intended parameters in both visits (n = 120)

Parameter	Visit 1	Visit 2	P-value*	ICC
Halo Size	27.20 ± 6.54	24.97 ± 21.79	0.158	0.975
Halo Intensity	28.13 ± 22.93	26.75 ± 22.04	0.455	0.857
Glare Size	23.80 ± 13.80	22.47 ± 15.46	0.332	0.760
Glare Intensity	38.42 ± 20.24	38.07 ± 18.53	0.853	0.779

Mean $\pm$ SD: mean and standard deviation

*Paired T-test with 0.05 was set as level of significance.

ICCs: Interclass correlation coefficients

Bland Altman plot analysis revealed the limits of agreement between measurements of halo size and intensity were within -20.00 and 23.55 (Fig. 3), and -18.00 and 21.23 (Fig. 4) respectively. The mean difference between the two visits were within 3.55 and 3.23 respectively in the 95% of our sample. Similarly for glare size and intensity, limits of agreement between measurements were within -14.34 and 21.55 (Fig. 5), and -20.00 and 21.23 (Fig. 6) respectively. The mean difference between the two visits were within 7.21 and 1.23 respectively in the 95% of our sample. This results indicates the reliability of measurements of Halo & Glare Simulator (Carl Zeiss Meditec AG, Germany) as PPT was very good.

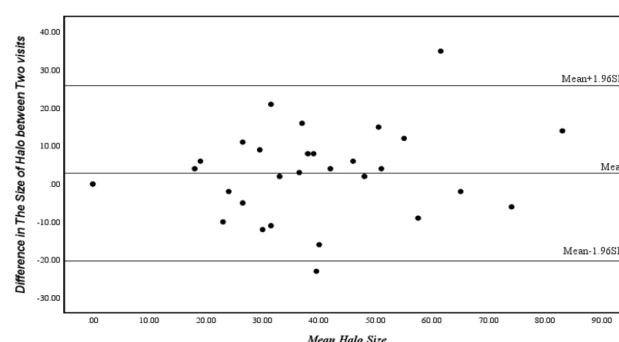


Fig 3 : Bland-Altman plot for halo size

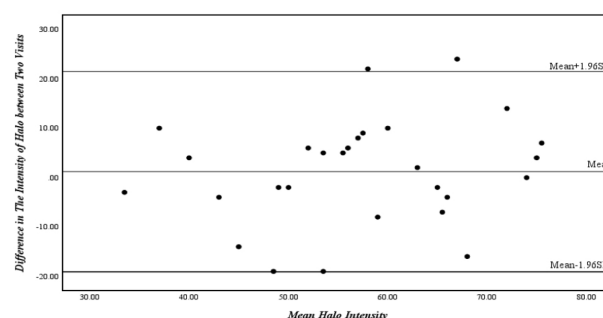


Fig 4 : Bland-Altman plot for halo intensity

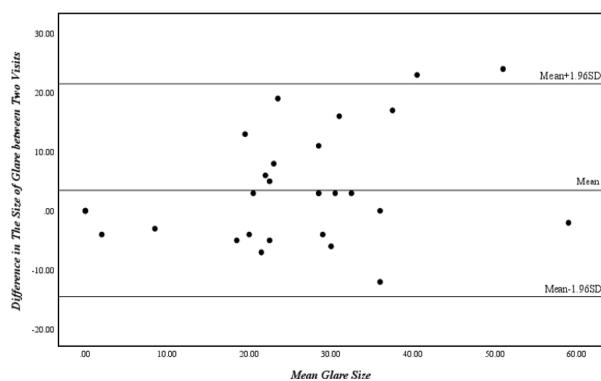


Fig 5 : Bland-Altman plot for glare size

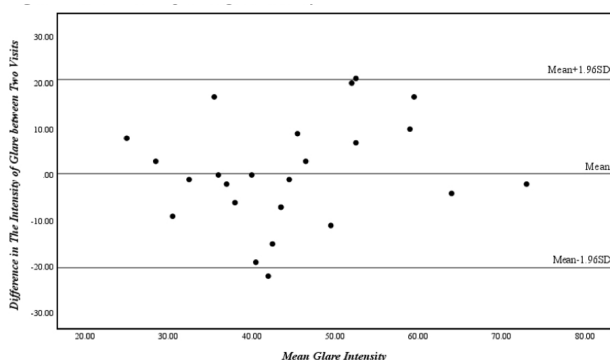


Fig 6 : Bland-Altman plot for glare intensity

DISCUSSION

Photic phenomena such as halo, glare and starbursts are common visual complaints especially while looking at headlights of vehicles, street lights or when driving at night. This impact is more prominent in patient who underwent refractive surgery (2,3,21). This study aimed to evaluate the reliability of Halo & Glare Simulator (Carl Zeiss Meditec AG, Germany) as PPT. This study confirmed that PPT could assess and identify different types of photic phenomena, namely, halo, glare and starburst.

Various approaches had been proposed to evaluate photic phenomena, in which mostly were conducted using questionnaires and simulators (22-25). Questionnaire-based studies were commonly utilised in evaluating photic phenomena in intraocular lens (IOL) studies. Recent works (3,7,8,26) have shown promising outcomes in evaluating photic phenomena with ranges of 20 - 70%. McAlinden et al. (27) had developed Quality of Vision (QoV) questionnaire in attempt to evaluate photic phenomena thru symptomology-based questionnaire. It has been reported that QoV able to measure the frequency, severity, and the level of bother of symptoms with good reliabilities (28,29). Another work Maxwell et al. (30) had commented on another version of questionnaire known as Assessment of Photic Phenomena and Lens Effects (APPLES) questionnaire. Although APPLES was deemed to be as useful as QoV,

its reliabilities were debatable as it has not undergone psychometric evaluation (31). Thus, the drawback of this approach is that the results of questionnaire-based studies were highly dependent on the reliability of subjective response of the participants/patients. This is due to it requires memory of their perception of photic phenomena and how frequent they going out at night. Nonetheless, it should be noted that PPT does provide good foundation as it able to evaluate the characteristics of photic phenomena, its severity and detect its changes from time to time.

With advancement of technology, computer-simulation software had been developed to address the impact of photic phenomena on visual quality as they can express what they perceived in a real-time situation. Thus, this will provide better understanding for clinicians in managing unsatisfactory visual quality. Zeiss Glaremeter Halo & Glare Simulator (Carl Zeiss Meditec AG) has been employed to assist patients in visualizing their visual disturbance by mimicking real-life experiences especially in cataract and refractive surgery with promising reliabilities (32,33). Previous study (4) had commented a report on Halo and Glare Simulator (Eyeland Design Network GmbH, Vreden, Germany) which were found able to adjust and project halo and glare in various sizes and intensities. However, they also found that the adjustments were not in a continuous way, and testing was not based on real-time actual light source. Thus, its reliability were rather limited. Another work (5) had reported another halo meter method which use real-time actual light sources. This halometer employed combine letters and light sources on a tablet screen, participants were asked to evaluate what they perceived. It was reported that it was effective in evaluating various types of halo and glare.

Another approach in evaluating haloes and glare is using forward scattering measurement known as optical quality analyser system (OQAS). OQAS has been reported to measure haloes objectively and accurately with good repeatability (34,35). It was reported that objective visual quality parameters measured using OQAS were not significantly associated with pupillary response to light, however significance towards haloes. We postulate that this could be due to OQAS was measured with an artificial pupil of 4.0 mm diameter. Previous work had commented that halo were experience by patients even with minimum pupil size, not to mention in individuals with large minimum pupil size (≥ 4 mm) which surely a significant visual disturbance (36). This is due to eyes with a larger minimum pupil receive more light and experience more haloes. Another potential of experiencing haloes is aberration. Several studies had reported that corneal higher-order aberrations (HoA) dependent on pupil size correlated significantly with haloes (37, 38)

However, there are several elements that should be

considered in this study. First, the evaluation distance (50cm) between the participant and the light source are much lower than in daily life. Photoc phenomena commonly perceived when looking at faraway objects such as streetlight lights of vehicle lights. Thus, the distance could affect the perceived and change the perception of photoc phenomena. Secondly, the age range of the participants in the present study was quite large. With visual quality considered at its peak between ages 17 to 30 years; the measurements reported herein constitute robust reference values derived from a well-defined and highly relevant age group of healthy young participants (age 18 to 42 years). Thirdly, contrast sensitivity add more values to visual quality also been measured to ensure normal contrast is obtained at baseline. Lastly, variations in methodology, glare source luminance, distance and measurement units pose difficulties when attempting to compare the present findings result with other studies that evaluate halo and glare. Some studies expressed halo size as its radius in millimeters (mm) at a distance of 30 cm (39,40), while others provide measurements in square degree (sqd) (41,42). Therefore, prudent consideration needs to be exercised when evaluating halo and glare as it involves subjective response, thus needs to be carefully evaluated as there is no gold standard definition and assessment for photoc phenomena. Future work on PPT evaluation could be expanded to explore the correlation between the preoperative ocular parameters, such as corneal shape, higher-order aberrations (HoA), and pupil width, and these findings can be used as possible clinical predictor to identify risk factors for postoperative photoc phenomena.

CONCLUSION

Halo & Glare Simulator (Carl Zeiss Meditec AG) is repeatable and reproducible in objectively evaluate and characterise halo and glare.

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REFERENCES

1. Ukai Y, Okemoto H, Seki Y, Nakatsugawa Y, Kawasaki A, Shibata T, Mito T, Kubo E, Sasaki H. Quantitative assessment of photoc phenomena in the presbyopia-correcting intraocular lens. *PLoS One*. 2021 Dec 1;16(12):e0260406. doi: 10.1371/journal.pone.0260406.
2. de Silva SR, Evans JR, Kirthi V, Ziaei M, Leyland M. Multifocal versus monofocal intraocular lenses after cataract extraction. *Cochrane Database Syst Rev*. 2016;12:CD003169. doi: 10.1002/14651858.CD003169.pub4.
3. Ribeiro FJ, Ferreira TB. Comparison of visual and refractive outcomes of 2 trifocal intraocular lenses. *J Cataract Refract Surg*. 2020;46(5):694–9. doi: 10.1097/j.jcrs.000000000000118.
4. Son HS, Khoramnia R, Yildirim TM, Baur I, Labuz G, Auffarth GU. Functional outcomes and reading performance after combined implantation of a small-aperture lens and a segmental refractive bifocal lens. *J Refract Surg*. 2019;35(9):551–8. doi: 10.3928/1081597X-20190806-02.
5. Buckhurst PJ, Naroo SA, Davies LN, Shah S, Buckhurst H, Kingsnorth A, Drew T, Wolffsohn JS. Tablet App halometer for the assessment of dysphotopsia. *J Cataract Refract Surg*. 2015;41(11):2424–9. doi: 10.1016/j.jcrs.2015.05.041.
6. Darian-Smith E, Versace P. Visual performance and positional stability of a capsulorhexis-fixated extended depth-of-focus intraocular lens. *J Cataract Refract Surg*. 2020;46(2):179–87. doi: 10.1097/j.jcrs.0000000000000044.
7. Bissen-Miyajima H, Ota Y, Hayashi K, Igarashi C, Sasaki N. Results of a clinical evaluation of a trifocal intraocular lens in Japan. *Jpn J Ophthalmol*. 2020;64(2):140–9. doi: 10.1007/s10384-019-00712-4.
8. Tan J, Qin Y, Wang C, Yuan S, Ye J. Visual quality and performance following bilateral implantation of TECNIS Symphony intraocular lenses with or without micro-monovision. *Clin Ophthalmol*. 2019;13:1071–7. doi: 10.2147/OPTH.S202380.
9. Cochener B. Influence of the level of monovision on visual outcome with an extended range of vision intraocular lens. *Clin Ophthalmol*. 2018;12:2305–12. doi: 10.2147/OPTH.S184712.
10. Jais FN, Che Azemin MZ, Hilmi MR, Mohd Tamrin MI, Kamal KM. Postsurgery Classification of Best-Corrected Visual Acuity Changes Based on Pterygium Characteristics Using the Machine Learning Technique. *Scientific World Journal*. 2021 Nov 15;2021:6211006. doi: 10.1155/2021/6211006.
11. Md Mustafa MMS, Abdul Mutalib H, Ab. Halim N, Hilmi MR. Accuracy of contact lens method by spherical and aspheric rigid gas permeable lenses on corneal power determination in normal eyes. *Sains Malaysiana*. 2020;49(6): 1431-1437.
12. Mohd Radzi H, Mohd Zulfaezal CA, Khairidzan MK, Mohd Izzuddin MT, Norfazrina AG, Tengku Mohd TS. Prediction of changes in visual acuity and contrast sensitivity function by tissue redness after pterygium surgery. *Curr Eye Res*. 2017;42:852–856.
13. Che Arif FA, Hilmi MR, Kamal MK, Ithnin MH (2021). Comparison of Immediate Effects on Usage of Dual Polymer Artificial Tears on Changes in Tear Film Characteristics, *Malaysian J Med Health Sci (MJMHS)*, 17(3): 252-258.
14. Hilmi MR, Khairidzan MK, Ariffin AE, Norazmar NA, Maruziki NN, Musa NH, Nasir MS, Azemin

- MZC, Azami MH, Abdul Rahim MAS. Effects of Different Types of Primary Pterygium on Changes in Oculovisual Function. *Sains Malaysiana*. 2020;49(2):383-388.
15. Hilmi MR, Azemin MZC, Khairidzan MK, Ariffin AE, Abdul Rahim MAS, Mohd Tamrin MI. Reliability of Pterygium Redness Grading Software (PRGS) in describing different types of primary pterygia based on appearance. *Sains Malaysiana*. 2020;49(5): 1015-1020.
16. Hilmi MR, Khairidzan MK, Azemin MZC, Azami MH, Ariffin AE. Corneo-ptyerygium Total Area Measurements Utilizing Image Analysis Method, *J Optom*, 2019;12(4): 272 - 277.
17. Che Azemin MZ, Hilmi MR, Mohd Tamrin MI, Mohd Kamal K. Fibrovascular redness grading using Gaussian process regression with radial basis function kernel. In *Biomedical Engineering and Sciences (IECBES)*, 2014 IEEE Conference on 2014 Dec 8 (pp. 113–116). IEEE.
18. Che Azemin MZ, Mohd Tamrin MI, Hilmi MR, Mohd Kamal K. Inter-grader reliability of a supervised pterygium redness grading system. *Adv Sci Lett* 2016;22(10):2885-2888. ISSN 1936-6612
19. Tarib I, Kasier I, Herbers C, Hagen P, Breyer D, Holland D, Lucchesi R, Teisch S, Auffarth GU, Gerl M, Kretz FTA. Benefits of a Rotationally Asymmetric Enhanced Depth of Focus, Bifocal Segment Intraocular Lens in an Older Cataract Population Ranging from 74 to 82 Years. *EC Ophthalmology*, 2018;9:248–256.
20. Savini G, Schiano-lomoriello D, Balducci N, Barboni P. Visual performance of a new extended depth-of-focus intraocular lens compared to a distance-dominant diffractive multifocal intraocular lens. *J Refract Surg*, 2018;34(4):228–235. <https://doi.org/10.3928/1081597X-20180125-01>.
21. Kawamura J, Tanabe H, Shoji T, Yamauchi T, Takase K, Tabuchi H. Comparison of visual performance between diffractive bifocal and diffractive trifocal intraocular lenses. *Sci Reps*. 2024;14(1), 5292. <https://doi.org/10.1038/s41598-024-55926-5>
22. Chang DH. Visual acuity and patient satisfaction at varied distances and lighting conditions after implantation of an aspheric diffractive multifocal one-piece intraocular lens. *Clin Ophthalmol*. 2016;10:1471–7. doi: 10.2147/OPTH.S108298
23. Han KE, Lee JE. Comparative Evaluation of Visual Performance and Patient Satisfaction following Cataract Surgery: A Retrospective Analysis of an Extended Depth-of-Focus Intraocular Lens and a Diffractive Multifocal Lens with Extended Depth of Focus. *J Clin Med*. 2023;12(23):7368. doi:10.3390/jcm12237368
24. Bvila FJ, Casado P, Marcell6n MC, et al. Subjective Straylight Index: A Visual Test for Retinal Contrast Assessment as a Function of Veiling Glare. *J Imaging*. 2024;10(4):89. doi:10.3390/jimaging10040089
25. Ungewiss J, Schiefer U, Eichinger P, Wurner M, Crabb DP, Jones PR. Does intraocular straylight predict night driving visual performance? Correlations between straylight levels and contrast sensitivity, halo size, and hazard recognition distance with and without glare. *Front Hum Neurosci*. 2022;16:910620. doi:10.3389/fnhum.2022.910620
26. Abdul-Kadir MA, Hilmi MR, Mohd Kamal K. Safety and efficacy of "hydro-fluorescein" technique in removing Tenon in pterygium surgery: a 1-year follow-up study. *Eye (Lond)*. 2025 Apr;39(6):1081-1085. doi: 10.1038/s41433-024-03539-7.
27. McAlinden C, Pesudovs K, Moore JE. The development of an instrument to measure quality of vision: The quality of vision (QoV) questionnaire. *Invest Ophthalmol Vis Sci*, 2010;51(11):5537–5545. <https://doi.org/10.1167/iov.10-5341>
28. Kim DR, Yoon YC, Whang WJ, Hwang HS, Na KS. Ocular parameters associated with visual performance of enhanced monofocal intraocular lens. *BMC Ophthalmol*. 2024;24(1):74. doi:10.1186/s12886-024-03316-w
29. Moore J, Wstergaard J, Kretz F. Visual performance and patient preference with bilateral implantation of an extended depth of focus or combined implantation of an extended depth of focus/trifocal intraocular lens. *Int Ophthalmol*. 2024;44(1):80. doi:10.1007/s10792-024-03030-y
30. Maxwell A, Holland E, Cibik L, Fakadej A, Foster G, Grosinger L, Moyes A, Nielsen S, Silverstein S, Toyos M, Weinstein A, Hartzell S. Clinical and patient-reported outcomes of bilateral implantation of a +2.5 diopter multifocal intraocular lens. *J Cataract Refract Surg*. 2017;43(1):29-41. doi: 10.1016/j.jcrs.2016.10.026. PMID: 28317674.
31. Grzybowski A, Kanclerz P, Muzyka-Woźniak M. Methods for evaluating quality of life and vision in patients undergoing lens refractive surgery. *Graefes Arch Clin Exp Ophthalmol*. 2019;257:1091–1099. <https://doi.org/10.1007/s00417-019-04270-w>
32. Lwowski C, Rusev V, Kohnen T. Assessment of Visual Habituation Measured With the Halo & Glare Simulator and Its Impact on Patient Satisfaction Following Quadrifocal IOL Implantation. *J Refract Surg*. 2023;39(8):510-517. doi:10.3928/1081597X-20230612-01.
33. Li LP, Yuan LY, Mao DS, Hua X, Yuan XY. Systematic bibliometric analysis of research hotspots and trends on the application of premium IOLs in the past 2 decades. *Int J Ophthalmol*. 2024;17(4):736-747. doi:10.18240/ijo.2024.04.19
34. Garcin T, Grivet D, Thuret G, Gain P. Using Optical Quality Analysis System for predicting surgical parameters in age-related cataract patients. *PLoS One*. 2020;15(10):e0240350. doi: 10.1371/journal.pone.0240350. PMID: 33044993; PMCID: PMC7549767.
35. Yao L, Xu Y, Han T, Qi L, Shi J, Zou Z, Zhou X.

- Relationships Between Haloes and Objective Visual Quality in Healthy Eyes. *Transl Vis Sci Technol*. 2020;9(10):13. doi: 10.1167/tvst.9.10.13.
36. Zhao F, Han T, Chen X, Chen Z, Zheng K, Wang X, Zhou X. Minimum pupil in pupillary response to light and myopia affect disk halo size: a cross-sectional study. *BMJ Open*. 2018;8(4):e019914. doi: 10.1136/bmjopen-2017-019914.
37. Md Rejab NS, Mohd Radzi H, Kamal, MK. (2023) Association Between Visual Performance and Aberration Using QIRC Questionnaire in Moderate and High Myopic Patient, *International Journal of Allied Health Sciences*, 7(5):268-279.
38. Teshigawara T, Meguro A, Mizuki N. The Effect of Age, Postoperative Refraction, and Pre- and Postoperative Pupil Size on Halo Size and Intensity in Eyes Implanted with a Trifocal or Extended Depth-of-Focus Lens. *Clin Ophthalmol*. 2021;15:4141-4152. doi: 10.2147/OPTH.S327660.
39. Babizhayev MA, Deyev AI, Yermakova VN, Davydova NG, Kuryshcheva NI, Doroshenko VS, Zhukotskii AV. Image analysis and glare sensitivity in human age-related cataracts. *Clin Exp Optom*. 2003;86(3):157-72. doi: 10.1111/j.1444-0938.2003.tb03098.x.
40. Babizhayev MA, Minasyan H, Richer SP. Cataract halos: a driving hazard in aging populations. Implication of the Halometer DG test for assessment of intraocular light scatter. *Appl Ergon*. 2009;40(3):545-53. doi: 10.1016/j.apergo.2007.09.003.
41. Lackner B, Pieh S, Schmidinger G, Hanselmayer G, Simader C, Reitner A, Skorpik C. Glare and halo phenomena after laser in situ keratomileusis. *J Cataract Refract Surg*. 2003;29(3):444-50. doi: 10.1016/s0886-3350(02)01816-3.
42. Allen RJ, Saleh GM, Litwin AS, Sciscio A, Beckingsale AB, Fitzke FW. Glare and halo with refractive correction. *Clin Exp Optom*. 2008;91(2):156-60. doi: 10.1111/j.1444-0938.2007.00220.x.
43. M&S Technologies Inc. M&S Smart System II Use and Operation Guide. Illinois, IMP-0706:2011
44. Kretz FT, Attia MA, Linz K, Auffarth GU. [Level of Binocular Pseudoaccommodation in Patients Implanted with an Apodised, Diffractive and Trifocal Multifocal Intraocular Lens]. *Klin Monbl Augenheilkd*. 2015;232:947-52.