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 ± SD) of halo size and intensity were 27.20 ± 6.54 and 28.13 ± 22.93 respectively. For glare size and intensity, mean ± SD were 23.80 ± 13.80 and 38.42 ± 20.24 respectively. For the second visit, the mean ± SD halo size and intensity were 24.97 ± 21.79 and 26.75 ± 22.04 respectively. For glare size and intensity, mean ± 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.
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Keywords: Glare, Halo, Reliability, Photic phenomena test, Visual disturbance

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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 ± SD) of halo size and intensity were 27.20 ± 6.54 and 28.13 ± 22.93 respectively. For glare size and intensity, mean ± SD were 23.80 ± 13.80 and 38.42 ± 20.24 respectively. For the second visit, the mean ± SD halo size and intensity were 24.97 ± 21.79 and 26.75 ± 22.04 respectively. For glare size and intensity, mean ± 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.

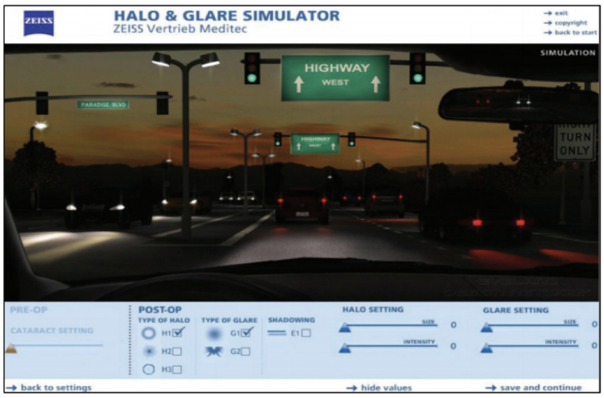

Fig 1 : computer-based Halo & Glare Simulator (Carl Zeiss Meditec AG, Germany).

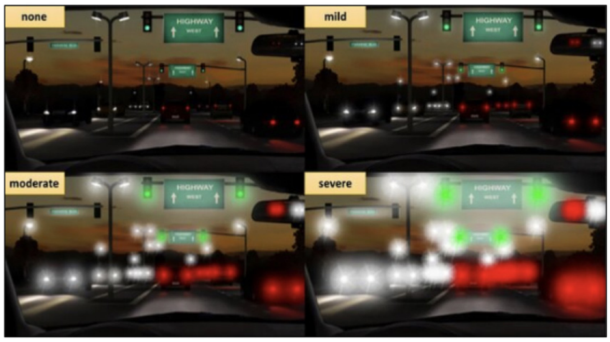

Fig 2 : Halo and Glare classification

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 ± 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 ± SD were 23.80 ± 13.80 and 38.42 ± 20.24 respectively. For the second visit, the mean and standard deviation (mean ± SD) halo size and intensity were 24.97 ± 21.79 and 26.75 ± 22.04 respectively. Whereas for glare size and intensity, the mean ± 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 ± 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.

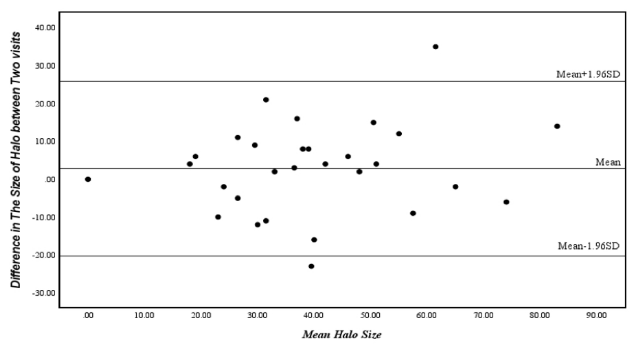

Fig 3 : Bland-Altman plot for halo size

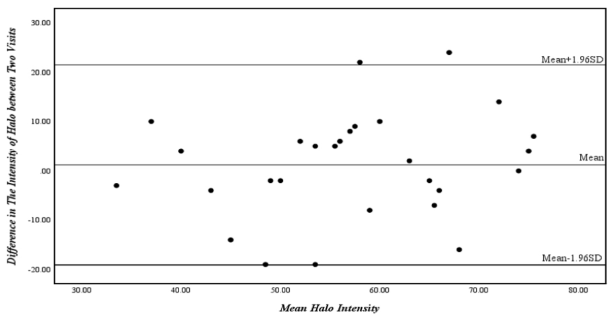

Fig 4 : Bland-Altman plot for halo intensity

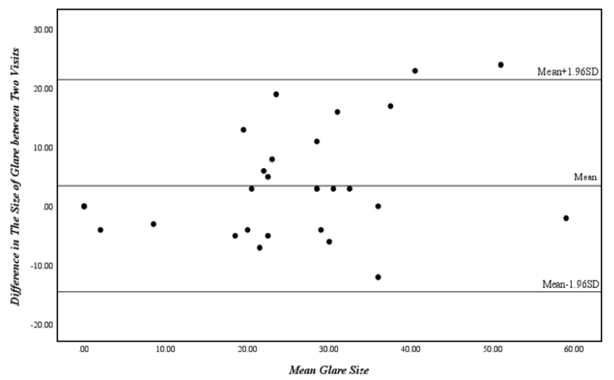

Fig 5 : Bland-Altman plot for glare size

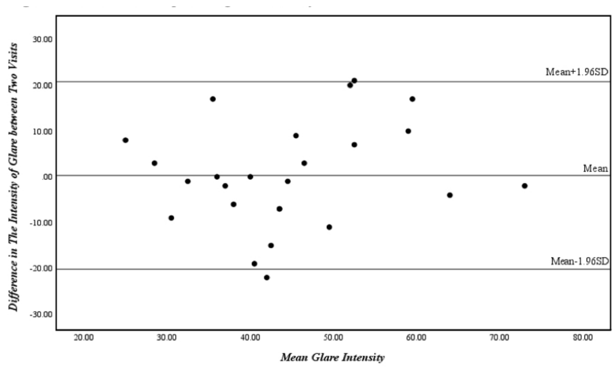

Fig 6 : Bland-Altman plot for glare intensity

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 of 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 ables 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. Photic 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 photic 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 photic 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 photic 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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