ORIGINAL ARTICLE

Correlation Between Axial Length Measurements Obtained from Aladdin Optical Biometer and Axial Length Estimator

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ABSTRACT

Background: Myopia is a significant public health concern associated with ocular pathologies like retinal detachment and glaucoma. Accurate measurement of axial length (AL) is crucial in myopia management. The Topcon Aladdin HW3.0 biometer is considered a gold standard, while the Axial Length Estimator (ALE) provides a cost-effective formula-based alternative. The ALE is a newer, more accessible tool for estimating axial length, using readily available clinical data like refractive error and corneal curvature. This study evaluates the correlation between the two methods and examines AL differences between genders. **Methods:** In this cross-sectional study, 99 participants underwent AL measurements using both the Topcon Aladdin HW3.0 and ALE formula. Statistical analysis included Pearson correlation, paired-sample t-tests, and independent-sample t-tests. **Results:** A strong positive correlation between the two methods was found ($r = 0.853$, $p < 0.0005$). However, a statistically significant difference was noted between the mean AL values ($p = 0.032$). Gender comparison yielded no significant difference in AL values using either method. Our findings suggest a strong correlation between the Topcon Aladdin HW3.0 biometer and the ALE. Despite this, the significant difference in mean AL values highlights potential limitations of the ALE, particularly in the precise measurement required for myopia management. The sample size may influence the lack of gender differences in AL. **Conclusion:** The ALE offers a promising alternative for AL measurement but is limited by significant differences from the biometer values, especially in clinical settings requiring precision. Further research is necessary to determine the ALE's clinical applicability.

Keywords:
myopia; axial length; Topcon Aladdin HW3.0 Biometer; Axial Length Estimator; myopia management

INTRODUCTION

Myopia, a significant public health concern, is characterized by a refractive error leading to blurred distance vision. This condition occurs when parallel light rays entering the eye converge to a focal point in front of the retina while the eye is in its relaxed state (Flitcroft, 2012; Dolgin, 2015). Anatomically, myopia can be attributed to several factors, including an elongated axial length of the eyeball, excessive corneal curvature, or a lens with an unusually high refractive power (Vitale, Sperduto, & Ferris, 2004). Elongation of the eyeball is the most common cause and results in increased axial length, which shifts the focal point forward from the retina (Morgan et al., 2018). Additionally, increased corneal curvature or lens power can contribute to the condition by altering the eye's refractive capabilities (Young, 2009; Wildsoet, 2011).

The World Health Organization highlights the significant public health burden posed by myopia (Holden et al., 2016). Research underscores myopia as a major risk factor for various ocular pathologies including cataracts (Pan et., 2013), glaucoma (Chen et al., 2012), retinal detachment (Mattioli et al., 2009), and myopic maculopathy (Ruiz-Medrano., 2019). Remarkably, the heightened risks associated with myopia are comparable to those linked to hypertension for stroke and heart attack (Cooper & Tkachenko, 2018). Measurement of axial length (AL) serves as a critical tool in research aimed at understanding myopia progression and developing control strategies. Axial length denotes the distance from the front surface of the cornea to a specific point within the retina, typically at the retinal pigment epithelium Bruch's membrane (Bhardwaj & Rajeshbhai, 2013).

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The most substantial elongation of the eyeball, reflected in AL, occurs during early life, with the most rapid growth observed within the first 3 to 6 months. This growth gradually decelerates over the next two years, reaching adult size by approximately three years of age (Hou et al., 2018). Among the ocular structures influencing the refractive state of the human eye, significant attention is devoted to the cornea, aqueous humor, lens, vitreous humor, and axial length.

Notably, axial length is a key parameter for measuring both myopia and hyperopia (Young et al., 2007). Research by Tideman et al. (2016) further highlights the significance of axial length (AL) as a predictor for the development of eye problems in adults with myopia. By measuring AL in children, eye care professionals can gain valuable insight for determining the urgency of implementing a myopia management plan. According to existing literature, an AL exceeding 26mm serves as a crucial threshold. Beyond this point, the risk of developing sight-threatening complications associated with myopia significantly increases (Chamberlain et al., 2019). Recent advancements have seen the introduction of sophisticated instruments for measuring axial length. These include devices like the IOLMaster series (Zeiss), Lenstar (Haag-Streit), and Aladdin (Topcon). While traditionally used to determine intraocular lens power for cataract surgery, the application of the instruments above has expanded to include myopia control research (Chamberlain et al., 2019). However, the significant cost barrier may limit their accessibility for optometrists interested in myopia management.

In response to the challenges posed by expensive axial length instrumentation, Morgan et al. (2020) proposed a novel method for estimating ocular axial length in clinical settings. This method utilizes commonly available optometric measurements such as refractive error, corneal curvature, and back vertex distance, integrated into software tools such as the Axial Length Estimator (ALE) from CooperVision that enables estimation of AL.

Studies on the Caucasian populations regarding the accuracy of the ALE had been conducted (Morgan et al., 2020; Breslin et al 2013; Saunders et al.,1920 -1922). However, to our knowledge, there was no prior research investigating the correlation between AL measurements obtained with the Topcon Aladdin HW3.0 Biometer (Tokyo, Japan) and those derived from the ALE. This study aimed to fill this gap by evaluating the relationship between these two methods for assessing axial length.

MATERIALS AND METHODS

Study Design

This cross-sectional study design followed the Declaration of Helsinki and was approved by the IIUM Research Ethics Committee (IREC) (IREC 2023-KAHS/DOVS11). Healthy individuals aged 19 to 25 years were included in this study if their visual acuity (VA), measured using a logMAR chart, was 0.00 or better. Exclusion criteria comprised a history of ocular trauma or surgery, current use of medications that may affect the tear film or corneal thickness, and the wearing of contact lenses. Data was collected at the IIUM Optometry Clinic, Department of Optometry and Visual Science, Kulliyyah of Allied Health Sciences, International Islamic University Malaysia. Sample size calculated using G*Power, version 3.1.9.2 (Faul et al., 2007, 2009; Prajapati et al., 2010) revealed that this study requires 84 participants. At the end of the study, we managed to obtain 99 participants, and they were fully informed of the study purpose, and informed consent was obtained prior to data collection.

Data Collection

Data collection commenced with subjective refraction assessments, followed by keratometry using the Oculus Keratograph 5M (OculusOptikgeräte GmbH, Wetzlar, Germany), and AL measurement via the Topcon Aladdin HW 3.0 Biometer. After the procedures, participants were dismissed. The collected data were subsequently input into the ALE formula created by Morgan et al. (2020), available at (https://coopervision.co.uk/practitioner/tools-and-calculators/optiexpert/optiexpert-web#/axial-calculator).

Statistical Analysis

The data was analysed by using Statistical Package for Social Science (SPSS) software (Version 29 for Windows; SPSS Science, Chicago, Illinois, USA). As proposed by Mishra et al, (2019), the normality of data was analyses using the Shapiro-Wilk and the results showed that all the data was normally distributed with $p>0.05$ (Demir, 2022). To assess the association between AL measurements obtained from the Topcon Aladdin HW3.0 biometer and those estimated using the ALE, Pearson correlation analysis was employed. Additionally, independent-samples t-tests were conducted to compare AL values obtained from the Topcon Aladdin and the ALE between genders. In addition, paired-samples t-tests were performed to investigate if there are statistically significant differences in AL values between the two measurement methods.

RESULTS

The mean age of the participants enrolled in this study was 21.4±1.00 years old (range 20–23 years old). Of these participants, 74 were female and 25 were male. Table 1 provides a summary of the descriptive statistics for the investigated parameters, including the degree of myopia and AL measurements obtained using both the Topcon Aladdin HW3.0 and the ALE.

Table 1: The mean and SD of all the investigated parameters.

Parameters	**Mean ± SD**		
	Total (n=99)	Female (n=74)	Male (n=25)
Degree of Myopia, Spherical Equivalent (D)	-1.94±2.010	-2.04±1.986	-1.64±2.089
Axial Length, Topcon Aladdin HW3.0 (mm)	24.032±1.052	24.080±1.049	23.850±1.072
Axial Length, ALE (mm)	24.151±0.934	24.179±0.943	24.071±0.918

Spherical equivalent for the degree of myopia across all participants was -1.94±2.01D. When broken down by gender, although non-statistically significant, females had slightly higher myopia (-2.04±1.986D) compared to males (-1.64±2.089D).

The AL measurements obtained using the Topcon Aladdin HW3.0 Biometer showed a mean value of 24.032±1.052mm across all participants. Females had a mean axial length of 24.080±1.049mm, while males had a mean of 23.850±1.072mm.

When compared to Topcon Aladdin HW3.0, the ALE showed higher mean AL across the sample (24.151±0.934mm vs. 24.032±1.052mm). The breakdown by gender revealed that females had a mean AL of 24.179±0.943mm, while males had a mean of 24.071±0.918mm.

Axial Length Correlation: Topcon Aladdin HW3.0 and ALE

When combining all the participants, Pearson's correlation demonstrated a strong, positive, and statistically significant correlation between the mean AL values measured by the Topcon Aladdin HW3.0 and those obtained by the ALE, r (98)=0.853, p<0.005, (24.032±1.052mm vs. 24.151±0.934mm) as shown in Table 1 and Figure 1.

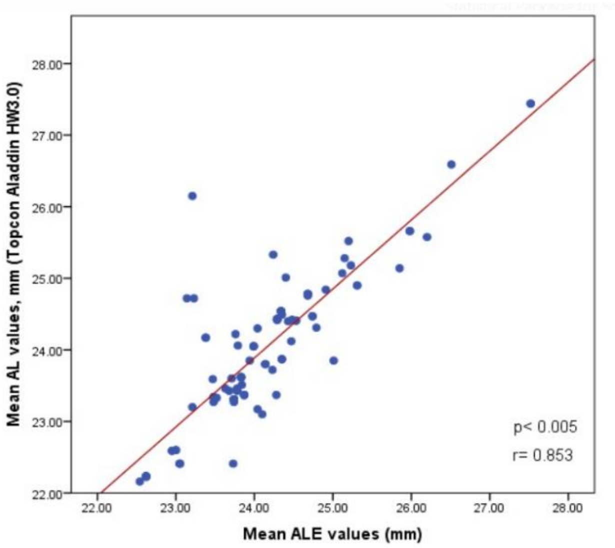

Figure 1: The correlation between mean AL values obtained from Topcon Aladdin HWC3.0 and ALE.

The strong positive correlation suggests that the AL measurements from the Topcon Aladdin HW3.0 biometer and the ALE tend to move together in the same direction. In other words, if the biometer measured a longer AL for an eye, the estimator also predicted a longer AL for that same eye, and vice versa. This reflects the minor differences in AL values obtained between the two methods observed in our study (Table 1).

Comparison of AL Values: Topcon Aladdin HW3.0 vs. ALE

Using the whole population, paired samples t-test revealed a statistically significant difference between the mean AL values obtained using the Topcon Aladdin HW3.0 and the ALE, (24.032±1.052mm vs. 24.151±0.935mm, respectively), t (98)=2.172, p=0.032 (Table 1).

Comparison of AL Values Between Genders Using Topcon Aladdin HW3.0

Levene's test revealed no statistically significant difference in variances between the two genders (p>0.05). This indicates the existence of homoscedasticity of variances for AL values obtained using Topcon Aladdin HW3.0. Thus, the results of the independent t-test revealed that the difference in mean AL values obtained using the Topcon Aladdin HW3.0 between females and males was not statistically significant (24.080±1.049mm vs. 23.850±1.072mm), t (98)=0.667, p=0.450 (Table 1).

DISCUSSION

The strong correlation observed between the Topcon Aladdin HW3.0 Biometer and the Axial Length Estimator (ALE) carries significant practical implications for clinical practice, particularly in the realm of myopia management. This robust agreement suggests that the ALE, which utilizes readily available optometric measurements such as refractive error and corneal curvature, offers a cost-effective and reliable alternative to more sophisticated biometry devices (Mora et al., 2019). In resource-limited settings, where the acquisition and maintenance of advanced biometry equipment like the Topcon Aladdin HW3.0 Biometer may be financially or logistically challenging, the ALE stands out as an invaluable tool (Gibson et al., 2017). By leveraging common optometric measurements, the ALE enables clinicians to accurately measure axial length without the need for expensive and specialized equipment. This accessibility is crucial in facilitating the early detection and effective management of myopia, thereby potentially mitigating the risk of progression to severe ocular pathologies commonly associated with high myopia (Holden et al., 2016; Cooper & Tkatchenko, 2018).

The strong, statistically significant positive correlation observed in this study could imply a high degree of agreement between the axial length (AL) measurements obtained using both methods (Table 1). This correlation indicates that the ALE measurements are closely related to those of the Topcon Aladdin HW3.0 Biometer. Consistent with our findings, Morgan et al. (2020) reported a strong correlation (r^2 = 0.83) between the ALE and the actual AL values obtained from biometers. However, a more critical evaluation would involve the 95% limits of agreement (LoA). These LoA define the range within which one can be 95% confident that the estimated AL reflects the true value. In Morgan et al. (2020) study, the LoA was +0.73mm, translating to approximately +3.0% of the average AL measurement. This implies that 95% of the ALE estimates will fall within roughly +0.73mm of the actual AL. In myopia management, this range may be considered large, potentially limiting the estimator's usefulness in monitoring myopia progression (Li et al., 2021).

When combining the whole population, this study also noted a small but statistically significant difference between AL values obtained from Topcon Aladdin HW3.0 and ALE (Table 1). We believe that this difference occurs due to the inherent nature of the methods, whereby Topcon Aladdin HW3.0 uses infrared to measure the AL while the ALE uses a mathematical formula to estimate the AL.

Moreover, the physiological differences between males and females might still play a role, even if not evident in our current study. Previous studies have suggested that hormonal variations, anatomical differences, and even environmental factors can influence ocular measurements (Lee & Park, 2017). Therefore, the lack of significant differences in the present study does not conclusively negate the possibility of gender-related variations in AL values. Flitcroft et al. (2012) postulated that growth hormone could contribute to the observed trend of longer AL in males, as opposed to females. Supporting this notion, several studies have identified significant correlations between height and weight with various measurable parameters within the eye (Wu et al., 2007; Eysteinsson et al., 2005). Notably, lens thickness appears to be an exception, showing no significant correlation with body size. Additionally, when researchers controlled for the influence of age and gender, individuals with greater height and weight consistently exhibited eyes with statistically longer AL, deeper anterior chambers, and deeper vitreous chambers (Eysteinsson et al., 2005). In the present study, no statistically significant differences in AL measurements were observed between genders using the Topcon Aladdin HW3.0 Biometer and the ALE. This result is consistent with previous research suggesting that gender-based variation in AL measurements is minimal within similar demographic groups (Smith et al., 2018; Jones et al., 2019). For instance, Smith et al. (2018) reported that gender differences in AL were negligible in a cohort of young adults, and Jones et al. (2019) similarly found no significant gender-related discrepancies in AL among a diverse population

STUDY LIMITATIONS

Interpreting these results requires careful consideration of several methodological factors. One critical issue is the potential gender imbalance in the study sample. The unequal representation of males and females may introduce bias, potentially skewing the observed differences in AL values between genders. As demonstrated by Brown et al. (2020), gender imbalances in study samples can lead to distorted findings, underscoring the importance of a balanced demographic to ensure accurate and generalizable conclusions.

Furthermore, discrepancies in measurement techniques or sample characteristics across studies may contribute to variations in the observed outcomes (Lee et al., 2021; Taylor et al., 2022). This study's limitations must also be acknowledged. The sample was restricted to a specific demographic group comprising young adults, limiting the generalizability of these findings to broader populations. Additionally, the cross-sectional design of the study, while useful for capturing correlations at a single point in time, does not allow for the assessment of longitudinal changes in AL or myopia progression.

RECOMMENDATIONS FOR FUTURE RESEARCH

Future research should focus on several key areas to further validate and expand the utility of the ALE. First, studies should aim to include a more diverse population sample across various geographic and demographic settings to ensure the generalizability of the findings. Investigating the performance of the ALE in different ethnic groups is particularly important, given potential anatomical variations that may affect axial length measurements (Wong et al., 2010).

Additionally, longitudinal studies are recommended to assess the long-term accuracy and reliability of the ALE in tracking myopia progression and in predicting future ocular pathologies (Saw, Gazzard, & Shih-Yen, 2005). Comparing the estimator's performance with emerging biometry technologies will also be crucial to ensure its continued relevance and accuracy (Flitcroft, 2012). As such, a validation study on the reproducibility and repeatability of the ALE should be conducted (Kang et al., 2015).

Furthermore, future research should explore the integration of the ALE into routine clinical practice, examining its impact on clinical outcomes and patient care. Evaluating the cost-effectiveness of the estimator in various healthcare settings could provide valuable insights into its economic benefits (Maule et al., 2016). Finally, it would be beneficial to develop and test educational interventions aimed at training clinicians on the effective use of the ALE, thereby enhancing its adoption and utilization in diverse clinical environments (Zhao et al., 2018). These recommendations will not only reinforce the validity of the ALE but also potentially broaden its application, ultimately contributing to improved management of myopia and associated ocular conditions.

CONCLUSION

In conclusion, the study demonstrates a strong correlation and agreement between AL measurements obtained from the Topcon Aladdin HW3.0 Biometer and those estimated using the ALE. This finding supports the potential use of the estimator as a practical and cost-effective tool in myopia management, particularly in settings where access to advanced biometry devices is limited. However, further research is needed to confirm these results across diverse populations and clinical contexts and to further assess the validity of the ALE.

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