MYOPIA INDIAN EYES: COMPARING CALCULATED AND MEASURED AXIAL LENGTH IN YOUNG PATIENTS

Ophthalmology

Nirav Mehta*

Hari Jyot College of Optometry, Associate Professor, Navsari, Gujarat, India.
*Corresponding Author

Shivani Kansara

Rotary Eye Institute, Optometrist, Navsari, Gujarat, India

Dr. Rupam Desai

Rotary Eye Institute, Chief Medical Officer, Navsari, Gujarat, India.

ABSTRACT

Myopia is the leading cause of preventable blindness in children and young adults in the world. As age increases axial length increasing risks of myopia for causing ocular morbidity including retinal detachment, glaucoma, myopic macular degeneration, and cataracts. In India, much patient eye examination done at primary eye clinic, where to estimate axial length is difficult.

Our aim of the study was to assess the reliability of formula by comparing Predicted Axial Length (AL) uses corneal radius and Spherical equivalent (SE) to the measured AL using Ocular Biometry.

Method: 96 myopic eyes were included, Comprehensive eye examination with Auto-refractometer using TOPCON-800 and Axial length with Ocular Biometry (IOL Master-500) Calculated Axial length with formula by using AVE-K and SE which is obtained from original Gullstrand simplified Schematic eye: $AL = (24.00 \times AVE - K / 7.80 - SE \times 0.40)$ for both K-reading.

Result: Mean Calculated AL (mm) was $24.67 \pm .90$ and Measured AL (mm) which was $24.28 \pm .96$ mm in 9-25yr age ($P < 0.001$) with Mean difference 0.3 ± 0.4 . All groups show statistically significant correlation between Calculate AL and Mean AL ($p < 0.01$, $r > 0.9$). The coefficient of determination (R^2) was 82% in 9-25yr age group.

Conclusion: Study provides strong agreement between Measured AL and Calculated AL. Alternate method of AL measurement with a calculated formula can be implemented in all primary eye care for predicting Axial length and managing myopic patients for monitoring myopia control.

KEYWORDS

Spherical Equivalent (SE), Average K-reading (AVE-K), Axial Length (AL).

INTRODUCTION

Refractive error is one of the most common causes of visual impairment around the world and the second leading cause of treatable blindness. In 2010, it was estimated that uncorrected refractive error was the most common cause of distance vision impairment, affecting 108 million persons, and the second most common cause of blindness globally (Holden et al., 2016), (Murthy et al., 2002).

Myopia is the leading cause of preventable blindness in children and young adults in the world with an estimated 22.9% of the world population, or 1.406 billion people, being affected. An additional 2.7% of people, 163 million, are estimated to have high myopia. If untreated, myopia can inhibit academic performance in children (Chen et al., 2018; Theophanous et al., 2018), (Theophanous et al., 2018).

A recent estimate suggests that visual impairment among preschool children will increase by 26% by 2060 with uncorrected refractive error comprising 69% of cases. Myopes carry higher risks of important causes of ocular morbidity including retinal detachment, glaucoma, myopic macular degeneration, and cataracts. (Theophanous et al., 2018)

In some communities with a high prevalence of myopia, myopic macular degeneration has been found to be the most frequent cause of irreversible blindness.

Myopic macular degeneration has been found to cause 12.2% of vision impairment in Japan (approximately 200 000 people). (Holden et al., 2016)

Myopia progresses with an increase in the axial length. When myopia progresses to pathologic myopia, macular complications such as choroidal neovascularization (CNV) and myopic traction maculopathy (MTM) develop and lead to vision loss. The increase in the axial length may be largely associated with clinical characteristics of these complications (Ohsugi et al., 2017). Axial length measurement importance in pediatric age group, but the question arrived is there a clinical necessity and are we routinely measured it?

Optometrist/Optician provides routine eye examinations, including ocular health assessments, and collaborates with ophthalmologists and family physicians to detect, diagnose and treat asymptomatic and symptomatic ocular pathology (Dobbelsteyn et al., 2015). Most of the eye care practitioners, optometrist or ophthalmologists don't routinely measure Axial Length in clinical practice due to lack of access to the

instrumentation and its expense. This is not the only reason, but its bit problematic measure for estimating myopia and its management. There is no doubt that there is necessity of measuring AL for a clinical trial or study of myopia management. Without this measurement, we simply cannot judge the effect of treatment and refractive control.

For practitioners who have their own small clinical setup, it becomes critical to identify patient axial length due to lack of optical Biometry. During a pediatric refractive checkup and eye examination, it's also needed to check some parameters for identifying the etiology of refractive error like corneal curvature, axial length, pupil size and anterior chamber depth etc.

The large scale studies on the growth of the ocular components suggest that the eye has reached its adult emmetropic axial length by the age of 13 years. (Bhardwaj & Rajeshbhai, 2013)

Most of the parameters can be identified from clinical instrument except axial length. Optical Biometry can be available in tertiary eye care centers and which are more cost effective and more space consuming instrument. For optometrist or practitioner who has small clinical set-up, it's not possible to identify axial length. So, the formula which comes up from the Schematic eye, which is $AL = (24.00 \times AVE / 7.80) - (SE \times 0.40)$ is more useful for axial length calculation. Purpose of the study is to check the agreement of this formula for identifying the axial length in small clinical set-up by comparing the calculated and Measured Axial length in young children and young adults.

Method

Participants

Ninety Six eyes with diagnosed Myopia (66 Female, $Age = 17.34$, $SD_{Age} = 4.50$) participated in this study. Patients were included in study, where 9 to 25yr aged myopic eyes with normal anterior and posterior segment findings. Patients were excluded due to previous history of ocular pathology, trauma, history of any surgery, presence of any ophthalmic condition that could alter AL. Myopia groups based on refractive error (Spherical Equivalent). Myopia ≤ -5.00 D and Myopia > -5.00 D were included

Design

A Prospective cross-sectional study was performed between September 2019 to March 2020. Patients were examined for detailed comprehensive examination including axial length measurement at Rotary Eye Hospital, Navsari. The study was to compare the readings

of Calculated Axial length (Formula) and Measured Axial length by IOL Master.

Methodology

The protocol was reviewed and approved by the institute according to Helsinki Declaration. Initial demographic details with informed consent were taken from parents and children.

Comprehensive eye examination was performed which include History, Torch light examination, Refraction and Fundus examination. Axial length measurement was done by IOL Master in all individuals with IOL master-500. Axial length was measured with five consecutive measurements with average of it than ACD was measured. Calculated axial length with formula $AL = (24.00 \times \text{aveK}/7.80) - (SE \times 0.40)$ Where aveK and SE denote average corneal radius and spherical equivalent, respectively. The patient was explained about their refractive error if there was a change.

Statistical analysis

Statistical analysis was done using IBM SPSS software version 26. Calculated Axial length and measured axial length data were normally distributed. Shapiro-wilk test was used to test the normality and box plot. Paired t Test, Independent t Test and Multiple regression analysis was used in this study.

RESULTS

Total 102 myopic patients were included with spherical equivalent ranging from -1.00 to -9.00. Shapiro-wilk normality test was performed for Calculated Axial length ($w(96) = 0.991, p > .746$) and Measured Axial length ($w(96) = 0.984, p > .305$) and in Box plot 6 eyes were removed as there were outliers in the data. Finally 96 eyes were included in the study as shown in table 1.

Table 1: Descriptive Statistics

Variables	Count	Percent
Gender		
Female	66	68.8
Male	30	31.3
Total	96	100
Age Group		
9 to 17	40	41.7
18 to 25	56	58.3
Total	96	100
Myopia Group		
Myopia ≤ -5.00 D	87	90.6
Myopia > -5.00 D	9	9.4
Total	96	100

A paired sample t-test suggested that there had been significant change in the calculated Axial length ($M = 24.67, SD = .96$) with Measured Axial length ($M = 24.28, SD = .90$), $t(95) = 9.431, p < .001$.

An independent sample t test reported a significant difference in Measured Axial length in different Myopia group, $t(94) = -3.68, p < .001, 95\% \text{ C.I. } (-1.68, -0.50)$. Myopia ≤ -5.00 Dsph patient having lower axial length ($M = 24.17, SD = 0.84$) as compared to Myopia > -5.00 Dsph ($M = 25.27, SD = 0.88$) patients. Similarly, Calculated Axial length in different Myopia group, $t(94) = -2.28, p < .05, 95\% \text{ C.I. } (-1.41, -0.098)$. Myopia ≤ -5.00 Dsph patient having lower axial length ($M = 24.60, SD = .96$) as compared to Myopia > -5.00 Dsph ($M = 25.36, SD = 0.75$) patients.

There was a significant correlation between the Measured AL and Calculated AL in All myopic eyes ($N=96, r=.90, p<.01$), Myopia ≤ -5.00 Dsph ($r=.90, p<.01$) and Myopia > -5.00 Dsph ($r=.78, p<.01$). There was a moderate correlation between the Measured AL and Spherical Equivalent in myopic eyes ($N=96, r=.598, p<.01$)

Table 2:- Multiple Regression summary for calculated Axial length

Variable	B	95% CI	B	T	Sig.
(Constant)	.426	[-2.52, 3.11]			.709
Measured Axial length	1.015	[.89, 1.13]	.944	20.74	.000
Myopia Group	.351	[-.78, -0.32]	-.106	-2.33	.022

Note $R^2 = .83 (N=96, p < .001)$, CI=Confidence interval for B

The multiple regression model as whole was significant to predict Calculated Axial length. $F(2,93) = 229.603, p < .001$ by ANOVA as shown in table 2.

Graph 1:- The lines in the scatter plots demonstrate the linear regression in calculated axial length and measured axial length in myopic groups.

Graph 2:- Bland Altman Plot of the mean differences of all myopic Eyes between calculated and measured axial length against the mean of each. The dotted lines represent the upper and lower 95% limits of agreement (mean difference $\pm 1.96 \times$ standard deviation (SD) of the differences). The central solid line represents the mean of the differences

DISCUSSION

Many patients present for routine eye examinations without symptoms of disease and are subsequently found to have pathology or risk of pathology that requires referral for secondary care. By providing comprehensive primary eye care, optometrists can expedite patient referrals to ophthalmologists, as well as other primary healthcare providers for consultation and management (Dobbelsteyn et al., 2015). In the present study, we investigated whether Calculated Axial length based on the equation $AL = (24.00 \times \text{aveK}/7.80) - (SE \times 0.40)$ can be used in Optical/Optomery clinic where Axial length measurement is difficult. The goal was to predict the calculated AL based on Measured AL and Myopic refractive error. In line with hypothesis, our results showed that there is strong positive correlation 82% between Measured AL and calculated AL in all Myopic Patients. In current study, Myopia groups shows 84% and 62% correlation in Myopia ≤ -5.00 Dsph and > -5.00 Dsph.

Multiple regression analysis showed R^2 for overall model is 83.2% with an adjusted R^2 of 82.8%, a strong size effect is reported by the model of variation in calculated Axial length accounted by linear combination of the predictor variables (Measured Axial length and Myopia Group as per Graph 1).

The accuracy of calculated ALs to measured ALs is variable according to groups of refractive errors, but in all groups the regress equation y (calculated AL) = $-0.432 + 1.025x$ (measured AL) ($r = 0.967, p < 0.001$) was verified with 696 eyes (Kim et al., 2019). Similarly final predictive equation was Calculated Axial length = $0.426 + 1.015(\text{Measured Axial length}) - 0.351(\text{Myopia Group})$

Band Altman plot (Myles & Cui, 2007) was designed to understand the difference in AL and Mean AL at 95% confidence interval. As shown in graph2, and patients having myopia ≤ -5.00 Dsph where Mean difference AL (0.426) with $\pm 1.96SD$ (1.16, 0.22).

Previous study projections indicate that by 2050, 50% and 10% of the world will have myopia and high myopia, respectively, (Holden et al., 2016). Similar study provides us same information that changes in the axial length in highly myopic eyes leads to various complications (Ohsugi et al., 2017)

Another study shows increased prevalence of 79.5% to 87.7% ($P < 0.05$) from year 2001 to 2015, Axial length was significantly associated with spherical equivalent, and both were associated with visual impairment. Projections of these risks to areas with a high incidence of myopia indicate that visual impairment will rise considerably as the population ages, and 1 in 10 persons will develop visual impairment in the most endemic regions (Wong et al., 2016).

Contrary to the findings, Overall Myopia Mean AL difference was 0.27 ± 0.49 by (Kim et al., 2019), matches with our study Mean AL difference was 0.30 ± 0.40 . In addition this study focuses on different Myopic group where Mean AL difference was 0.40 ± 0.38 and 0.09 ± 0.5 in Myopia ≤ -5.00 and > -5.00 dsph respectively.

Most important limitation is Sample size was less in patients with Myopia group > -5.00 dsph. In spite the results showed minimal AL difference of 0.09 ± 0.5 $p > .630$ which validate that Calculated AL based on equation can be implemented in practice.

Summary & conclusion

In the present article, showed a strong agreement between Calculated AL formula for myopic patients in optometry/optical clinic where AL measuring instruments are not available. The results of studies suggested that difference of AL measurement with Calculated AL and Measured AL is minimal. Future research may extend this work by implementing in different optometry/optical clinic to predict the AL for managing or controlling myopia to prevent global trends.

REFERENCES:

1. Bhardwaj, V., & Rajeshbhai, G. P. (2013). Axial length, anterior chamber depth-a study in different age groups and refractive errors. *Journal of Clinical and Diagnostic Research*, 7(10), 2211–2212. <https://doi.org/10.7860/JCDR/2013/7015.3473>
2. Chen, M., Wu, A., Zhang, L., Wang, W., Chen, X., Yu, X., & Wang, K. (2018). The increasing prevalence of myopia and high myopia among high school students in Fenghua city, eastern China: A 15-year population-based survey. *BMC Ophthalmology*, 18(1), 1–10. <https://doi.org/10.1186/s12886-018-0829-8>
3. Dobbeltsteyn, D., Mckee, K., Beames, R. D., Jayanetti, S. N., Persaud, D. D., & Cruess, A. F. (2015). What percentage of patients presenting for routine eye examinations require referral for secondary care? A study of referrals from optometrists to ophthalmologists. *Clinical and Experimental Optometry*, 98(3), 214–217. <https://doi.org/10.1111/cxo.12255>
4. Holden, B. A., Fricke, T. R., Wilson, D. A., Jong, M., Naidoo, K. S., Sankaridurg, P., Wong, T. Y., Naduvilath, T. J., & Resnikoff, S. (2016). Global Prevalence of Myopia and High Myopia and Temporal Trends from 2000 through 2050. *Ophthalmology*, 123(5), 1036–1042. <https://doi.org/10.1016/j.ophtha.2016.01.006>
5. Kim, H. S., Yu, D. S., Cho, H. G., Moon, B. Y., & Kim, S. Y. (2019). Comparison of predicted and measured axial length for ophthalmic lens design. *PLoS ONE*, 14(1). <https://doi.org/10.1371/journal.pone.0210387>
6. Murthy, G. V. S., Gupta, S. K., Ellwein, L. B., Muñoz, S. R., Pokharel, G. P., Sanga, L., & Bachani, D. (2002). Refractive error in children in an urban population in New Delhi. *Investigative Ophthalmology and Visual Science*, 43(3), 623–631.
7. Myles, P. S., & Cui, J. (2007). I. Using the Bland-Altman method to measure agreement with repeated measures. *British Journal of Anaesthesia*, 99(3), 309–311. <https://doi.org/10.1093/bja/aem214>
8. Ohsugi, H., Ikuno, Y., Shoujou, T., Oshima, K., Ohsugi, E., & Tabuchi, H. (2017). Axial length changes in highly myopic eyes and influence of myopic macular complications in Japanese adults. *PLoS ONE*, 12(7), 5–13. <https://doi.org/10.1371/journal.pone.0180851>
9. Theophanous, C., Modjtahedi, B. S., Batech, M., Marlin, D. S., Luong, T. Q., & Fong, D. S. (2018). Myopia prevalence and risk factors in children. *Clinical Ophthalmology*, 12, 1581–1587. <https://doi.org/10.2147/OPTH.S164641>
10. Wong, K. T., Kuijpers, R. W. A. M., Vingerling, J. R., Hofman, A., Buitendijk, G. H. S., Keunen, J. E. E., Boon, C. J. F., & Klaver, C. C. W. (2016). Association of Axial Length With Risk of Uncorrectable Visual Impairment for Europeans With Myopia. *134*(12), 1355–1363. <https://doi.org/10.1001/jamaophthalmol.2016.4009>