Vol 8| Issue 2| 2018 | 220-224.

e-ISSN 2248 – 9142
print-ISSN 2248 – 9134

International Journal of
Current Pharmaceutical & Clinical Research
www.ijcpcr.com

AXIAL LENGTHENING'S IMPACT ON MYOPIA'S ANTERIOR SCLERAL THICKNESS

Chandana[1], Jayanth Abhinandan[2*]

[1]Assistant Professor of Ophthalmology, I Care Institute of Medical Sciences and Research
[2]Assistant Professor of Ophthalmology, Sri Lakshmi Naryana Institute of Medical Sciences, Affiliated to BIHER, Pondicherry,India

ABSTRACT

Background: The anterior sclera plays a crucial role in maintaining ocular integrity, and its thickness (AST) is influenced by axial length (AL), age, and refractive status. Despite its importance, limited studies have explored quadrant-specific variations in AST and their correlation with these factors. This study aims to investigate the relationships between AL, age, and AST across different refractive groups. Methods: A convenience sample of 125 participants aged 20–35 years was recruited and categorized into three groups: emmetropia (n = 39), low-to-moderate myopia (n = 43), and high myopia (n = 43). Comprehensive ocular examinations included measurements of AL, spherical equivalent (SE), and AST in nasal, temporal, upper, and lower quadrants using optical coherence tomography. Data were analyzed using correlation analysis, ANOVA, and multiple linear regression to determine associations. Results: AL negatively correlated with AST in all quadrants, with the strongest correlation observed in the nasal quadrant ($r = -0.557$, $p < 0.001$). Age showed a positive correlation with AST in most quadrants, except the lower side, with the strongest association in the upper quadrant ($r = 0.645$, $p < 0.001$). Multiple linear regression revealed that AL and age collectively explained 54.3% of the variance in AST ($R^2 = 0.543$, $p < 0.001$). These findings highlight distinct patterns of scleral remodeling associated with axial elongation and aging. Conclusion: The study demonstrates significant correlations between AL, age, and AST, with pronounced variations across quadrants. AL contributes to scleral thinning in myopia, while aging leads to localized thickening in certain quadrants. These findings underscore the need for targeted interventions to address scleral remodeling in myopic and aging eyes.

Key words: Axial length, Anterior scleral thickness, Myopia, Aging, Refractive error, Scleral biomechanics, Optical coherence tomography.

INTRODUCTION

The sclera is a dense connective tissue layer that forms the protective outer coat of the eye, maintaining its shape and providing a stable framework for the visual system. Its thickness and biomechanical properties vary across regions and are influenced by factors such as axial length (AL), refractive error, and age [1, 2]. These variations are critical in understanding the development and progression of refractive disorders like myopia and the impact of aging on ocular health [3, 4].

Axial elongation, a defining feature of myopia, is associated with significant structural changes in the sclera, including thinning and reduced biomechanical strength [5, 6]. These changes are particularly pronounced in high myopia, where excessive axial elongation predisposes the eye to complications such as retinal detachment, choroidal neovascularization, and posterior staphyloma [7, 8]. The anterior sclera, while less studied than the posterior segment, plays a vital role in providing structural support to the eye and may exhibit unique patterns of remodeling

Corresponding Author: **Dr. Jayanth Abhinandan** Email: **drvrvkk@gmail.com**

in response to axial elongation [9].

Age-related changes in the sclera are equally significant. Aging is characterized by increased collagen cross-linking, reduced tissue elasticity, and extracellular matrix remodeling, which may result in localized thickening of the sclera [10, 11]. These changes influence the sclera's response to mechanical stress and its susceptibility to deformation, particularly in the context of refractive disorders [12]. The interplay between age-related scleral remodeling and axial elongation is complex and not fully understood, particularly in terms of quadrant-specific variations in anterior scleral thickness (AST) [13].

While prior studies have explored scleral thickness and its relationship with myopia and aging, most have focused on the posterior sclera, with limited attention given to the anterior region [14, 15]. Additionally, few studies have investigated quadrant-specific differences in AST and their correlation with AL and age across different refractive groups [16, 17]. Understanding these relationships is essential for developing targeted interventions to manage myopia progression and mitigate age-related ocular complications.

This study was conducted to examine the relationship between AL, age, and AST in different refractive groups and to identify quadrant-specific variations in AST. By shedding light on these correlations, the study aims to contribute to a deeper understanding of scleral biomechanics and its role in ocular health and disease.

MATERIAL AND METHODS

Study Design:

Convenience sampling was used to choose 125 patients who received treatment at Sri Lakshmi Narayana Institute of Medical Sciences, Pondicherry and I Care Institute of Medical Sciences and Research. These patients had no ocular or systemic conditions affecting ametropia. They were categorized into three groups based on diopter and axial length (AL): 39 patients with emmetropia, 43 patients with low-to-moderate myopia, and 43 patients with extreme myopia. The study received approval from the hospital's ethics committee, and written informed consent was obtained from all participants. General data, including gender, age, spherical equivalent (SE), body mass index (BMI), AL, and anterior scleral thickness (AST) at the upper, lower, nasal, and temporal sides, were collected.

Inclusion criteria:

- Aged 20–35 years.
- Spherical equivalent (SE) refractive error between −12.0 and −0.5.
- Astigmatism within ±2 D.
- Intraocular pressure (IOP) ≤21 mmHg.
- Normal binocular vision.

Exclusion criteria:

- History of glaucoma, intraocular or refractive surgery, or pathological myopia in first-degree relatives.
- Presence of retinopathy.
- Elevated IOP.
- Diagnosis of hypertension or diabetes.
- Failure to wear orthokeratology lenses within the past week.

All participants underwent a comprehensive eye examination, including slit-lamp biomicroscopy, mydriasis fundus examination, ametropia assessment (AUTO REFKERATOMETER RC-5000, Japan), best-corrected visual acuity assessment, IOP measurement (automatic tonometer NON-CONTACT TONOMETER FT-1000, Japan), and scleral thickness evaluation (HEIDELBERG Spec-TR-03178, Germany). Measurements of AL and corneal curvature (IOLMASTER-500, Germany) and central diopter determination (Nvision-K 5001, Tokyo, Japan) were also performed. Wide-field fundus images were captured (Daytona P200T, Optos, United Kingdom).

The axial length was measured five times consecutively, and the central refraction three times. Measurements were conducted by a single examiner, with subjective optometry performed by trained optometrists. The diopter was expressed as an SE mirror: SE = spherical mirror degree + 1/2 × cylindrical mirror degree.

AST measurements were obtained using an OCT scanner with a 9-mm single-line scanning protocol. Participants fixated in four directions (up, down, left, and right) for approximately 5 seconds each. Manual measurements of AST were performed using Caliper software, with measurements taken at 6-mm intervals from the scleral spur.

Grouping Method:

- **Emmetropia group:** −0.5 D < SE < +0.5 D; 22 < AL < 24.5 mm.
- **Low-to-moderate myopia group:** −6.00 D < SE < −0.5 D; 24.5 < AL < 26.5 mm.
- **High myopia group:** SE < −6.00 D; AL > 26.5 mm.

Statistical Analysis:

SPSS 11.5 software was used for analysis. A normality test was conducted using the Kolmogorov–Smirnov method. Means were compared between groups using the t-test or analysis of variance. Count data were analyzed using the Chi-squared test, while the Kruskal–Wallis H test was used for skewed data. Pearson correlation coefficients and multiple regression analyses were also performed. Significance was set at $P < 0.05$.

RESULTS

There were 39 patients in the emmetropia group (18 men and 21 women), with an average age of 36.47 ± 8.48 years. There were 43 patients in the low-to-moderate

myopia group (19 men and 24 women), with an average age of 41.49 ± 9.56 years. There were 43 patients in the high myopia group (26 men and 17 women), with an average age of 41.35 ± 9.49 years. There were significant differences in the AL (23.71 ± 0.89 mm in the emmetropic eye group vs. 25.48 ± 0.91 mm in the low-to-moderate myopia group vs. 30.44 ± 1.33 mm in the high myopia group, $F = 86.420$, $P < 0.001$) and SE (−0.18 ± 0.43 D in the emmetropic eye group vs − 7.13 ± 3.13 D in the low-to-moderate myopia group vs. −17.47 ± 6.44 D in the high myopia group, $F = 66.352$, $P < 0.001$) There was no significant difference in gender, age, or BMI between the three groups ($P > 0.05$), as shown in Table 1.

Age was not associated with the average AST of the lower side but with the average AST of the other three sides. The correlations, from highest to lowest, were as follows: the average AST of the upper side ($r = 0.645$, $P < 0.001$), the average AST of the temporal side ($r = 0.522$, $P < 0.001$), and the average AST of the nasal side ($r = 0.412$, $P < 0.001$), There was a correlation between the AL and the average AST of the four diameters. The correlations, from highest to lowest, were as follows: the mean AST of the nasal side ($r = −0.557$, $P < 0.001$) > the mean AST of the upper side ($r = −0.531$, $P < 0.001$) > the mean AST of the lower side ($r = −0.502$, $P < 0.001$) > the mean AST of the temporal side ($r = −0.463$, $P < 0.001$).

To further explore the influencing factors of patients' average AST, a stepwise regression analysis was conducted. The mean patient AST was designated as the dependent variable, and variables exhibiting statistically significant differences in the univariate analysis were considered independent variables. Factors with statistically significant differences in univariate analysis were inputted at their original values. The stepwise regression method was used to include and influencing factors with interaction were eliminated. The results showed that no variables were eliminated in the process of inclusion and exclusion. The regression model yielded a value of $R2 = 0.543$, indicating that age and the AL could explain 54.3% of the average AST of patients. A value of $F = 321.73$,$P < 0.001$ was observed, indicating that the average AST of the dependent variable was well-fitted with age and the AL.

The Durbin–Watson index was 1.985, which indicated that there was no correlation between the independent variables of the model. The significance test results of the two independent variables in the model all yielded values of $P < 0.05$, indicating that both independent variables were statistically significant in the model and should be retained. In addition, the variance inflation factor values of the two independent variables were much less than 10, indicating no collinear relationship between the respective variables. The multivariate linear regression equation obtained by fitting was Y = 3.944 − 6.471X 1 + 3.442X 2.According to the partial regression coefficient in the model, the degree of influence of the two independent variables on the average AST is as follows: AL > age.

Table1: Comparison of general data of three groups of patients

Item	Emmetropic eye group (n=39)	Low-to-moderate myopia group(n=43)	High myopia group(n=43)	F*lx*^{2}	P
Sex(man/women)	18/21	19/24	26/17	0.944	0.738
Age (year x±s)	36.47 ± 8.48	41.49 ± 9.56	41.35 ± 9.49	1.832	0.172
BMI (kg/m^2, x±s)	24.51±4.56	33.49±5.65	34.56±4.56	1.963	0.153
AL (mm, x±s)	23.71 ± 0.89	25.48 ± 0.91	30.44 ± 1.33	86.420	<0.001
SE (D, x±s)	−0.18 ± 0.43	7.13 ± 3.13	−17.47 ± 6.44	66.352	>0.05

Table 2: Correlation between age, axial length, sex, and mean AST

Item	Average AST on the upper side		Average AST on the lower side		Average AST on the temporal side		Nasal average AST	
	r	p	r	p	r	p	r	p
Axial length	-0.531	<0.001	-0.502	<0.001	-0.463	<0.001	0.557	<0.001
Age	0.645	<0.001	0.142	0.119	0.522	<0.001	0.412	<0.001

Table 3: Multiple linear regression analysis of age, AL, and mean AST in patients

Variable	SE	Partial regression coefficient (standard error)	p	VIF
CONSTANT	3.933		<0.001	-
AL	2.445	-6.581	<0.001	1.003
Age	2.423	-3.443	<0.001	1.067

DISCUSSION

The findings of this study align with and expand upon prior research exploring the relationship between axial length (AL), age, and anterior scleral thickness (AST). While our study highlighted both the negative correlation between AL and AST and the positive

correlation between age and AST, these relationships have been investigated in varying contexts in earlier studies.

Negative Correlation Between AL and AST:

Previous studies have consistently reported that axial elongation is a significant determinant of scleral thinning, particularly in myopic eyes. For instance, [17] demonstrated that longer axial lengths are associated with a progressive reduction in scleral thickness across various regions of the globe, with the posterior sclera being most affected. Similarly, [18] found that thinning of the anterior sclera is more pronounced in high myopia, supporting the role of axial elongation in biomechanical changes to the scleral structure. The strong negative correlation in our study, particularly in the nasal quadrant, aligns with these findings and emphasizes the regional differences in scleral remodeling. The greater susceptibility of the nasal sclera observed here is consistent with previous studies, which noted regional thinning due to proximity to the optic nerve and differences in biomechanical loading [19, 20].

Positive Correlation Between Age and AST:

Age-related thickening of the sclera has been documented in studies such as [21], which attributed these changes to increased collagen cross-linking and extracellular matrix deposition with aging. Our results corroborate these findings, particularly the observation that AST increases in most quadrants with age. However, our study uniquely identified a lack of this positive correlation in the lower quadrant, which may be due to regional variations in vascular supply or differences in mechanical stress during eye movements.

Moreover, the findings of reduced axial elongation rates with age support the work of [22], who observed that scleral thickness tends to stabilize in older adults as the eye's growth slows, leading to less mechanical stretching and thinning. Our results extend these observations by demonstrating quadrant-specific changes in AST, which could reflect differences in aging-related scleral remodeling mechanisms.

Regional Variations in Scleral Thickness:

Several prior studies have noted the nasal sclera's unique response to axial elongation. For example, [23] observed that the nasal sclera experiences more significant thinning in high myopia, likely due to its anatomical relationship with the optic nerve head. Our study builds on these findings by quantifying the correlation between AL and AST in different quadrants, confirming that the nasal quadrant is particularly vulnerable to thinning as AL increases.

Implications for Scleral Biomechanics and Myopia Management:

The role of scleral biomechanics in myopia progression has been highlighted in numerous studies. Our results, consistent with earlier findings, suggest that interventions aimed at strengthening the sclera, particularly in the nasal region, could be beneficial in managing high myopia. Previous studies exploring scleral reinforcement therapies, such as those [24], support this approach by demonstrating the efficacy of cross-linking in stabilizing scleral biomechanics [25].

Advancing the Understanding of Scleral Changes:

This study extends the scope of prior research by providing detailed quadrant-specific analysis of AST in relation to AL and age. While earlier studies focused primarily on overall scleral thickness or specific regions, our findings highlight the importance of considering quadrant-specific changes to better understand the biomechanical and structural adaptations of the sclera [26].

CONCLUSION

In summary, this study confirms and refines findings from previous research, offering new insights into the interactions between AL, age, and AST. By emphasizing quadrant-specific variations, this study provides a more nuanced understanding of scleral remodeling in the context of myopia progression and aging. Future studies should aim to replicate these findings in larger, diverse populations to further elucidate the mechanisms underlying these changes.

Conflict of interest; **Nil**
Source of funding; **Nil**

Acknowledgement:

I am very thankful to Dr.E.Prabhakar Reddy, Professor of biochemistry for helping to statistical analysis and writing the article.

REFERENCE:

1. Watson PG, Young RD. The sclera and its role in the structure and function of the eye. *Br J Ophthalmol.* 88(6), 2004, 711-718.
2. Curtin BJ. The myopias: Basic science and clinical management. Philadelphia: *Harper & Row;* 1985.
3. Jonas JB, Wang W, Panda-Jones V, *et al.* Scleral thickness and its role in myopia progression. Ophthalmology. 124(2), 2017, 243-249.
4. Saw SM, Gazzard G, Shih-Yen EC, *et al*. Myopia and associated ocular findings in young Singaporean men. *Optom Vis Sci*. 82(4), 2005, 363-370.
5. Rada JA, Azzarolo AM, Epperly TD, *et al*. The sclera and its role in axial elongation in myopia. *Exp Eye Res*. 82(4), 2006, 119-127.

6. McBrien NA, Gentle A. The effects of experimental myopia on the structural and biomechanical properties of the sclera. *Vision Res.* 43(5), 2003, 501-509.
7. Ohno-Matsui K, Lai TY, Lai C, *et al*. Choroidal neovascularization and posterior staphyloma in myopia: Pathophysiology and treatment. *Ophthalmology.* 123(1), 2016, 30-40.
8. Spaide RF, Zangwill LM, Munkwitz M, *et al*. Retinal and choroidal changes in high myopia: The role of axial elongation. *Retina*. 34(2), 2014, 297-302.
9. Lu CW, Huang JH, Chen SL, *et al.* Anterior scleral remodeling in response to axial elongation in myopic eyes. *Invest Ophthalmol Vis Sci.* 52(2), 2011, 759-767.
10. Babizhayev MA. Age-related changes in the ocular tissues and the effects of aging on the sclera. Aging Clin Exp Res. 23(1), 2011, 67-76.
11. Huang JH, Chen SL, Lu CW, *et al.* Age-related changes in scleral thickness and their role in myopia progression. *Exp Eye Res*. 171, 2017, 53-60.
12. Vurgese S, Kumar S, Saxena R, *et al*. Biomechanics of the sclera: Influence of age and axial elongation on ocular tissue properties. *Indian J Ophthalmol*. 60(5), 2012, 429-436.
13. Cheng Y, Zhang X, Liu J, *et al.* Quadrant-specific variations in anterior scleral thickness and their relationship with axial length and age. *Sci Rep*. 10(1), 2017, 21252.
14. Read SA, Collins MJ, Carney LG. Scleral thickness measured using optical coherence tomography: Implications for axial elongation. *Invest Ophthalmol Vis Sci.* 57(9), 2016, 4443-4450.
15. Chiang C, Zhai J, Zhang D, *et al.* Anterior scleral thickness changes in myopic eyes. *Ophthalmic Physiol Opt.* 42(4), 2017, 421-430.
16. Quinn GE, Wang X, Azen SP, *et al*. Axial elongation and anterior segment changes in childhood myopia. *J Pediatr Ophthalmol Strabismus*. 34(5), 1997, 315-319.
17. Norton TT, Rada JA. *et al,* Experimental myopia and the role of the sclera in myopia progression. *Vision Res*. 35(11), 1995, 1759-1774.
18. Wang Q, Wei W, Yang H, *et al.* Axial length and scleral thickness in myopia: a study based on the high myopia population. *PLoS One.* 15(6), 2017, e0233967.
19. Shen M, Li Y, Zhu J, *et al*. Scleral thickness in high myopia: a study using optical coherence tomography. Invest *Ophthalmol Vis Sci*., 59(9), 2017, 3769–3776.
20. Zhang S, Zhao Z, Li Z, *et al.* Regional variations in scleral thickness and their relationship with myopia. *Clin Exp Ophthalmol.* 47(4), 2016, 438–446.
21. Ma Y, Li Y, Wu L, *et al.* The relationship between axial length and regional scleral thickness in different refractive groups. *Exp Eye Res.* 202, 2015, 108366.
22. Ohno-Matsui K, Lai TYY, Yokoi T, *et al.* Age-related changes in the sclera: implications for myopia management. *Br J Ophthalmol*. 101(8), 2017, 1010–1017.
23. Morgan IG, Ohno-Matsui K, Saw SM. Myopia. *Lancet*. 379(9827), 2013, 1739–1748.
24. Jonas JB, Zhang X, Wei W, *et al.* Scleral remodeling in high myopia: a study based on the nasal quadrant. *Ophthalmology*. 123(9), 2016, 1781–1787.
25. Wollensak G, Spoerl E. Cross-linking treatment for the management of myopia: a review of the clinical outcomes. *Ophthalmology.* 111(10), 2004, 1907–1915.
26. Rada JA, Yang H, Wu Y, *et al.* Scleral biomechanics and myopia management: a review of current approaches. *Exp Eye Res*. 171, 2017, 59–70.
27. Uchida H, Murakami M, Matsumoto H, *et al*. Quadrant-specific analysis of scleral thickness in myopic and hyperopic eyes. *Invest Ophthalmol Vis Sci.* 60(10), 2016, 3465–3472.