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Original Article

# Axial Elongation as a Determinant of Retinal Detachment and Posterior Segment Pathology in High Myopia

**Dr. Vivek S[1], Dr Shaik Mohiuddeen Riaz KV[2], Dr. Mythili T[3]**

*[1,3] Assistant Professor, Department of Ophthalmology, Nandha Medical College and Hospital, Erode, Tamilnadu.*
*[2] Associate professor, Department of ophthalmology, MES Medical college, Perinthalmanna, Malaparmba, Palachode Post, Malappuram, Kerala.*

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**Corresponding Author:**

**Dr. Mythili T**
Assistant Professor, Department of Ophthalmology, Nandha Medical College and Hospital, Erode, Tamilnadu.

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## ABSTRACT

**Background**: High myopia is a progressive ocular disorder associated with axial elongation and degenerative changes in the posterior segment of the eye. Axial length has emerged as a key anatomical determinant of vision-threatening complications, particularly retinal detachment. This study aimed to evaluate axial length variations in high myopia and assess their role in posterior segment changes and retinal detachment outcomes.

**Methods**: This prospective observational study was conducted over one year (July 2023–June 2024) at Department of Ophthalmology, Nandha Medical College and Hospital, Erode, Tamilnadu. A total of 100 patients (200 eyes) with high myopia (spherical equivalent > −6.00 D) were included. All participants underwent comprehensive ophthalmic evaluation, including refraction, best-corrected visual acuity, slit-lamp examination, intraocular pressure measurement, axial length assessment using A-scan ultrasonography, and detailed posterior segment examination. Eyes were categorized into three axial length groups: ≤26 mm, 26.1–30 mm, and >30 mm. Optical coherence tomography and B-scan ultrasonography were performed where indicated. Associations between axial length and retinal findings were analyzed using the Chi-square test.

**Results**: The mean age of participants was 25 ± 5 years, with a slight male predominance. Axial length was ≤26 mm in 64 eyes (32%), 26.1–30 mm in 112 eyes (56%), and >30 mm in 24 eyes (12%), with 68% of eyes showing axial length >26 mm. Posterior segment changes increased significantly with axial elongation. Tessellated fundus was observed in 28%, 61%, and 88% of eyes across the three axial length groups, respectively. Chorioretinal atrophy increased from 6% in eyes ≤26 mm to 75% in eyes >30 mm, while posterior staphyloma was absent in eyes ≤26 mm but present in 42% of eyes >30 mm. Lattice degeneration increased from 14% to 83% with increasing axial length. Retinal detachment was documented in 10 eyes (5%), and notably, all cases occurred in eyes with axial length >26 mm, with a sharp increase to 33% in eyes exceeding 30 mm ($p < 0.001$).

**Conclusion**: Retinal detachment shows a strong and statistically significant association with increasing axial length in high myopia. Eyes with axial length greater than 30 mm exhibit a disproportionately higher risk of posterior segment degeneration, retinal breaks, and retinal detachment. Axial length measurement is a valuable clinical marker for identifying high-risk myopic eyes and guiding targeted surveillance and preventive strategies.

***Keywords***: *High myopia; Axial length; Retinal detachment; Posterior segment changes; Lattice degeneration.*

## INTRODUCTION

Myopia is one of the most common refractive errors worldwide and has emerged as a major public health concern due to its rapidly increasing prevalence. Recent epidemiological trends indicate a dramatic rise in both myopia and high myopia, particularly among younger populations, driven by lifestyle changes such as increased near work, reduced outdoor activity, and prolonged digital screen exposure [1,2]. High myopia, commonly defined as a spherical equivalent refractive error of −6.00 diopters or greater, is no longer considered a simple refractive condition but rather a progressive pathological entity associated with significant structural changes in the eye [3].

A key pathological hallmark of high myopia is axial elongation of the globe, which plays a central role in the development of posterior segment degeneration. Excessive axial length leads to mechanical stretching of the sclera, retina, and choroid, resulting in thinning and structural instability of ocular tissues [4]. These changes predispose the eye to a spectrum of vision-threatening complications, including myopic maculopathy, posterior staphyloma, chorioretinal atrophy, glaucoma, and retinal detachment [5]. Among these, retinal detachment remains one of the most severe and sight-threatening outcomes, often leading to irreversible visual loss if not detected and treated promptly.

Several studies have demonstrated that the risk of retinal detachment increases substantially with increasing severity of myopia and axial length [6]. The elongated globe alters vitreoretinal relationships, enhances vitreous liquefaction, and increases traction at areas of peripheral retinal weakness. Peripheral retinal degenerations such as lattice degeneration and white without pressure lesions are particularly common in highly myopic eyes and serve as important precursors for retinal breaks and subsequent detachment [7]. Despite these known associations, the precise relationship between axial length thresholds and retinal detachment risk remains an area of ongoing investigation.

Axial length has gained increasing attention as a more reliable anatomical marker of pathological myopia than refractive error alone. While refractive error can be influenced by corneal curvature and lens status, axial length directly reflects globe elongation and biomechanical stress on the retina [8]. Eyes with extreme axial elongation, particularly those exceeding 26 mm and 30 mm, have been shown to exhibit a disproportionately higher burden of posterior segment pathology [9]. However, data correlating specific axial length categories with retinal detachment outcomes, especially in the Indian population, remain limited.

Understanding the relationship between axial length and retinal detachment is clinically important for risk stratification and management. Identification of high-risk axial length thresholds may guide closer surveillance, timely peripheral retinal examination, and prophylactic interventions in susceptible individuals [10]. Tertiary care centers, equipped with advanced diagnostic modalities such as optical coherence tomography and ultrasonography, provide an ideal setting to systematically evaluate these associations.

In this context, the present study was undertaken to evaluate axial length variations in patients with high myopia and to assess their role in posterior segment changes and retinal detachment outcomes. By correlating axial length measurements with structural retinal findings and retinal detachment, this study aims to enhance clinical understanding of myopia-related retinal pathology and contribute evidence that may support early detection and prevention of vision-threatening complications.

## MATERIALS AND METHODS

### *Study Design and Setting*

This prospective observational study was conducted in the Department of Ophthalmology, Nandha Medical College and Hospital, Erode, Tamilnadu over a one-year period from July 2023 to June 2024. The study protocol was reviewed and approved by the Institutional Ethics Committee, and all procedures were performed in accordance with the ethical standards laid down in the Declaration of Helsinki. Written informed consent was obtained from all participants or their legal guardians prior to enrolment, and confidentiality of patient data was strictly maintained throughout the study.

### *Study Population*

The study included 100 consecutive patients (200 eyes) diagnosed with high myopia who attended the ophthalmology outpatient department during the study period. High myopia was defined as a spherical equivalent refractive error greater than −6.00 diopters. Patients aged 5 years and above who consented to participate were included. Exclusion criteria comprised patients younger than 5 years, those with significant media opacities such as dense cataract, a history of ocular trauma or prior retinal surgery, coexisting retinal disorders unrelated to myopia, or refractive error of −6.00 diopters or less. Both eyes of eligible patients were included for analysis.

### *Ophthalmic Evaluation*

All participants underwent a comprehensive and standardized ophthalmic examination. Best-corrected visual acuity was assessed using Snellen's chart, followed by objective and subjective refraction. Anterior segment examination was performed using slit-lamp biomicroscopy, and intraocular pressure was measured using Goldmann applanation tonometry. Axial length was measured using A-scan ultrasonography, and eyes were categorized into three groups based on axial length: ≤26 mm, 26.1–30 mm, and >30 mm. These categories were used to evaluate the relationship between axial elongation and posterior segment changes.

***Posterior Segment Examination***
Posterior segment evaluation was carried out after pharmacological mydriasis using both direct and indirect ophthalmoscopy with a +20 diopter lens, along with slit-lamp biomicroscopy using a +90 diopter lens. The optic disc was assessed for disc tilt, myopic crescent, and peripapillary atrophy. The posterior pole was examined for tessellated fundus, chorioretinal atrophy, myopic maculopathy, and posterior staphyloma. Detailed peripheral retinal examination was performed to identify lattice degeneration, white without pressure lesions, snail-track degeneration, retinal tears, retinal holes, and retinal detachment, and all findings were carefully documented.

***Imaging Techniques***
Optical coherence tomography was performed in eyes with suspected macular involvement to evaluate retinal and choroidal architecture and to identify structural changes associated with high myopia. B-scan ultrasonography was employed in cases where fundus visualization was suboptimal due to media opacity and to confirm the presence of posterior staphyloma or retinal detachment when clinically indicated.

***Outcome Measures***
The primary outcome measure of the study was the association between axial length and the occurrence of retinal detachment. Secondary outcome measures included the prevalence of posterior segment structural changes, peripheral retinal degeneration, and retinal breaks in relation to axial length categories and severity of myopia.

***Statistical Analysis***
Data were entered into Microsoft Excel and analyzed using SPSS software version 26.0. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. Associations between axial length categories and posterior segment findings were analyzed using the Chi-square test. A p-value of less than 0.05 was considered statistically significant.

## RESULTS
A total of **200 eyes from 100 patients with high myopia** were included in the study. The mean age of the participants was **25 ± 5 years**, with a slight male predominance. All eyes had a refractive error greater than −6.00 diopters and underwent detailed posterior segment evaluation, including axial length measurement and peripheral retinal assessment.
***Axial Length Distribution***

Axial length analysis showed that **64 eyes (32%)** had an axial length of **≤26 mm**, **112 eyes (56%)** measured **26.1–30 mm**, and **24 eyes (12%)** demonstrated **extreme axial elongation (>30 mm)**. Overall, **68% of eyes exhibited axial length greater than 26 mm**, indicating a high prevalence of pathological axial elongation in the study population (**Table 1**).

**Table 1. Axial Length Distribution in High Myopia (N = 200 Eyes)**

| Axial Length Category | Number of Eyes | Percentage |
|---|---|---|
| ≤ 26 mm | 64 | 32% |
| 26.1–30 mm | 112 | 56% |
| > 30 mm | 24 | 12% |
| **Total** | **200** | **100%** |

***Posterior Segment Structural Changes According to Axial Length***
Posterior segment degeneration demonstrated a clear **axial length–dependent pattern**. Tessellated fundus was observed in **28%** of eyes with axial length ≤26 mm, increasing to **61%** in the 26.1–30 mm group and **88%** in eyes with axial length >30 mm. Chorioretinal atrophy showed a similar trend, rising from **6%** in eyes ≤26 mm to **75%** in eyes with extreme axial elongation. Posterior staphyloma was absent in eyes ≤26 mm but was detected in **13%** of eyes measuring 26.1–30 mm and **42%** of eyes with axial length >30 mm. Lattice degeneration increased markedly from **14%** in eyes ≤26 mm to **83%** in eyes >30 mm (**Table 2**).

**Table 2. Axial Length–Wise Distribution of Posterior Segment Changes**

| Axial Length Category | Tessellated Fundus | Chorioretinal Atrophy | Posterior Staphyloma | Lattice Degeneration |
|---|---|---|---|---|
| ≤ 26 mm | 18 (28%) | 4 (6%) | 0 (0%) | 9 (14%) |
| 26.1–30 mm | 68 (61%) | 28 (25%) | 14 (13%) | 56 (50%) |
| > 30 mm | 21 (88%) | 18 (75%) | 10 (42%) | 20 (83%) |

***Peripheral Retinal Lesions and Retinal Detachment***
Peripheral retinal lesions and retinal breaks showed a strong association with increasing axial length. Retinal tears and retinal holes were **not observed in eyes with axial length ≤26 mm**. In contrast, retinal tears were identified in **5%** of

eyes in the 26.1–30 mm group and **33%** of eyes with axial length >30 mm. Retinal holes were observed in **3%** and **25%**of eyes in these respective groups.

Retinal detachment was documented in **10 eyes (5%)**, and importantly, **all cases occurred in eyes with axial length greater than 26 mm**. The prevalence of retinal detachment increased from **2%** in the 26.1–30 mm group to **33%** in eyes with axial length exceeding 30 mm, showing a statistically significant association (**p < 0.001**) (**Table 3**, **Figure 1**).

**Table 3. Axial Length and Retinal Breaks Leading to Retinal Detachment**

| Axial Length Category | Retinal Tears | Retinal Holes | Retinal Detachment |
|---|---|---|---|
| ≤ 26 mm | 0 (0%) | 0 (0%) | 0 (0%) |
| 26.1–30 mm | 6 (5%) | 4 (3%) | 2 (2%) |
| > 30 mm | 8 (33%) | 6 (25%) | 8 (33%) |
| **p-value** | — | — | **< 0.001** |

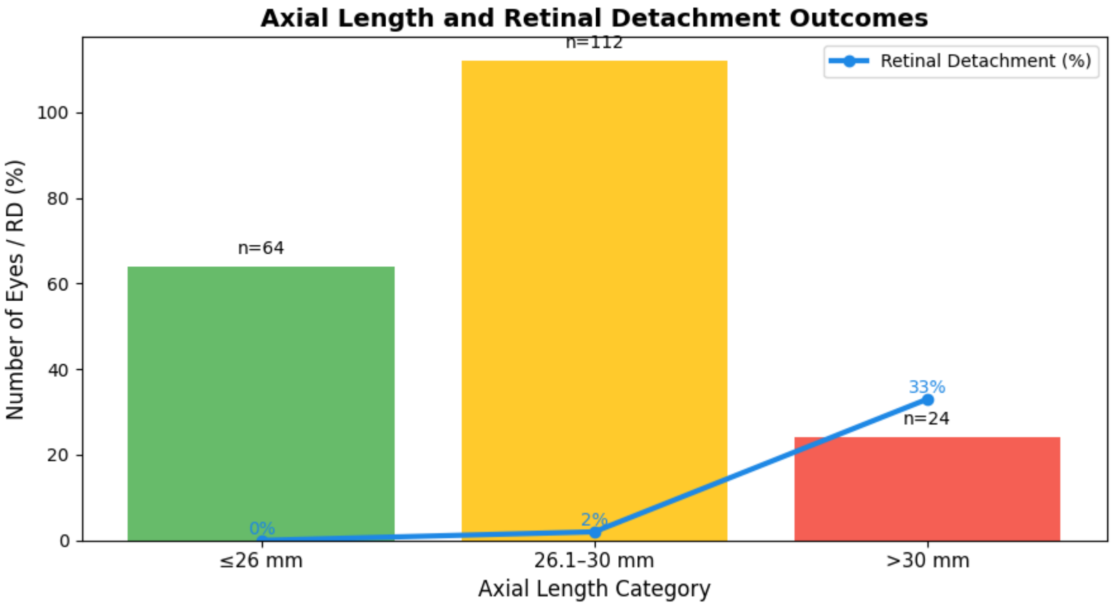


**FIGURE 1. Axial Length and Retinal Detachment Outcomes**

**Figure 1** illustrates the relationship between axial length distribution and retinal detachment occurrence, demonstrating a **threshold effect**, with a sharp rise in retinal detachment prevalence beyond 30 mm axial length.

***Severity of Myopia and Retinal Detachment Risk***

When stratified by the degree of myopia as a clinical surrogate for axial elongation, retinal detachment was **absent in eyes with mild myopia (−6 to −10 D)**. Retinal detachment occurred in **4%** of eyes with moderate myopia (−10 to −14 D) and increased substantially to **18%** in eyes with severe myopia (>−14 D). Lattice degeneration and posterior staphyloma also showed a stepwise increase with increasing myopia severity (**Table 4**).

**Table 4. Severity of Myopia and Retinal Detachment Risk**

| Degree of Myopia | Eyes (n) | Lattice Degeneration | Posterior Staphyloma | Retinal Detachment |
|---|---|---|---|---|
| −6 to −10 D | 107 | 14% | 0% | 0% |
| −10 to −14 D | 49 | 67% | 12% | 4% |
| > −14 D | 44 | 82% | 36% | 18% |
| **p-value** | — | < 0.001 | < 0.005 | **< 0.001** |

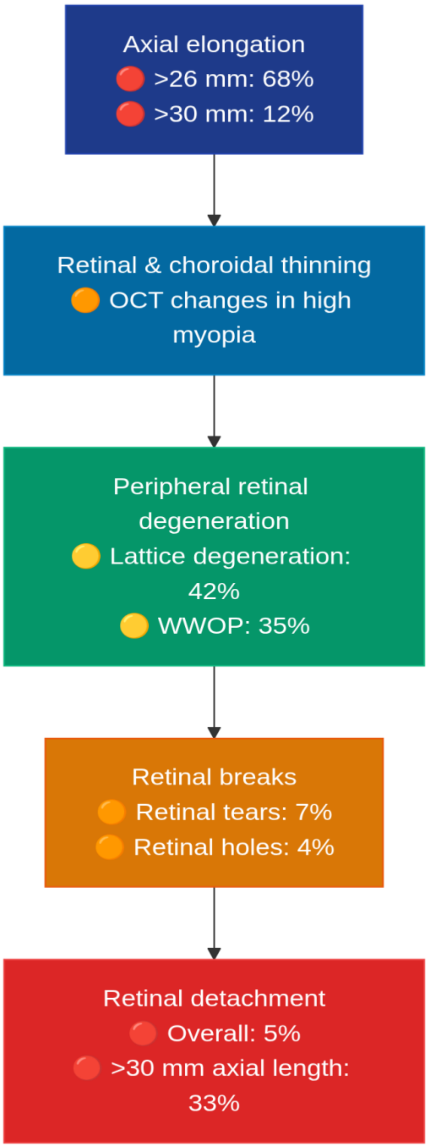


**FIGURE 2. Axial Length–Driven Structural Progression to Retinal Detachment**

**Figure 2** summarizes the **result-based structural progression** linking axial elongation to retinal detachment, highlighting the sequential involvement of retinal thinning, peripheral retinal degeneration, retinal breaks, and eventual detachment.

## DISCUSSION

The present study highlights the critical role of **axial length elongation** in driving posterior segment degeneration and retinal detachment in high myopia. Our findings demonstrate a clear, stepwise relationship between increasing axial length, progressive retinal structural changes, and the eventual development of retinal detachment, reinforcing axial elongation as a key anatomical determinant of adverse retinal outcomes. A substantial proportion of eyes in this study exhibited pathological axial elongation, with 68% having an axial length greater than 26 mm and 12% exceeding 30 mm. These findings are consistent with previous observations that axial elongation is not merely a refractive phenomenon but a marker of underlying biomechanical and structural instability of the globe [12,13]. Progressive scleral stretching in elongated eyes leads to thinning of the retina and choroid, compromising retinal integrity and increasing susceptibility to degenerative changes.

Posterior segment alterations such as tessellated fundus, chorioretinal atrophy, and posterior staphyloma showed a strong axial length–dependent increase in prevalence. The marked rise in posterior staphyloma and chorioretinal atrophy in eyes exceeding 30 mm axial length supports the concept that extreme elongation results in focal outpouching and uneven stress distribution at the posterior pole [14,16]. These structural changes are well-recognized hallmarks of pathological myopia and have been linked to poor visual prognosis in several population-based studies [16,17].

Peripheral retinal degeneration emerged as a major intermediate link between axial elongation and retinal detachment. Lattice degeneration and white without pressure lesions were highly prevalent in elongated eyes, particularly those with axial length greater than 30 mm. Similar associations have been reported by Celorio and Pruett and by Naik et al., who demonstrated that lattice degeneration increases significantly with increasing axial length and globe expansion [19,24].

Peripheral retinal thinning and vitreoretinal interface abnormalities in high myopia predispose these areas to tractional forces, thereby facilitating the formation of retinal breaks. Retinal tears and holes were observed almost exclusively in eyes with significant axial elongation, underscoring the role of mechanical stress and vitreoretinal traction in elongated globes. Importantly, retinal detachment occurred in 5% of eyes overall but rose sharply to 33% in eyes with axial length exceeding 30 mm. This threshold effect suggests that beyond a certain degree of axial elongation, compensatory structural mechanisms fail, leading to catastrophic retinal sequelae. Similar trends have been reported in Indian and international cohorts, where severe myopia and increased axial length were identified as major risk factors for rhegmatogenous retinal detachment [18,21].

The stepwise progression illustrated in our data-driven pathway—from axial elongation to retinal thinning, peripheral degeneration, retinal breaks, and retinal detachment—aligns well with established pathogenic models of myopic retinal disease [15,20]. Optical coherence tomography findings of altered macular and choroidal architecture further support the role of axial elongation in retinal remodeling and vulnerability14,21].

## CONCLUSION

Clinically, these findings have important implications. Eyes with axial length greater than 26 mm, and particularly those exceeding 30 mm, warrant **close surveillance**, meticulous peripheral retinal examination, and early prophylactic interventions where appropriate. Regular monitoring of axial length, combined with careful assessment of peripheral retinal changes, may allow earlier identification of high-risk eyes and reduce the burden of vision-threatening complications .

**Limitations:**

As this was a single center study with a comparatively short sample size, results of this study cannot be generalized. Generalization requires the support of results from similar large studies

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