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# Types of Astigmatism in the Young with Emphasis on Oblique Astigmatism

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## ABSTRACT

**Background:** Astigmatism is common in young individuals and shows characteristic axis patterns that evolve with ocular development. Oblique astigmatism, although less frequent than with-the-rule (WTR) and against-the-rule (ATR) forms, is clinically important because it can degrade functional vision and contribute to orientation-specific deficits when uncorrected early in life.
**Objectives:** To describe the distribution of astigmatism types in patients aged 4–40 years attending a tertiary-care ophthalmology outpatient department, with focused analysis of oblique and bi-oblique astigmatism by magnitude, axis range, laterality, age group, gender, and eye involved.
**Methods:** A hospital-based cross-sectional study was conducted from June 2025 to August 2025 at the Ophthalmology Outpatient Department, Government General Hospital, Srikakulam. Refractive data from 350 patients (700 eyes) with astigmatism were analyzed. Astigmatism was categorized into WTR, ATR, oblique, and bi-oblique patterns, and cylinder magnitude and axis distributions were summarized.
**Results:** WTR astigmatism was most frequent, followed by ATR. Oblique and bi-oblique patterns together constituted nearly one-quarter of astigmatic eyes. Within oblique/bi-oblique eyes, most cylinders were mild to moderate, and axes clustered predominantly within 121°–149° and 31°–59° ranges. Oblique/bi-oblique astigmatism was slightly more frequent in males and showed the highest distribution in adolescents.
**Conclusion:** In this OPD-based young cohort, WTR remained the dominant astigmatic pattern, while oblique/bi-oblique astigmatism represented a substantial minority. Routine axis-specific screening and timely optical correction in children and adolescents are essential to optimize visual function.

***Keywords****: astigmatism; with-the-rule; against-the-rule; oblique astigmatism; refractive error; young population.*

## INTRODUCTION

Astigmatism is among the most frequently encountered refractive errors in clinical practice and remains an important cause of uncorrected visual impairment in children and young adults[1–3]. In addition to reducing high-contrast acuity, astigmatic blur can affect contrast sensitivity, reading speed, and visually demanding near tasks. These effects are influenced not only by cylinder magnitude but also by axis orientation and interocular symmetry [4,5]. In school-age groups, even low-to-moderate cylinders can translate into sustained blur during learning activities when correction is delayed or inconsistent[6].

Axis orientation is clinically meaningful. With-the-rule (WTR) astigmatism often predominates in younger age groups, while against-the-rule (ATR) patterns increase with advancing age, reflecting age-related biomechanical and optical changes of the cornea and crystalline lens [13,14]. Regular astigmatism typically aligns close to the vertical or horizontal meridians, whereas oblique astigmatism lies away from these cardinal axes. For an equivalent cylinder power, oblique axes can cause greater perceived blur and can be less well tolerated, which is relevant for spectacle acceptance and visual comfort [6–10].

The pediatric implications of astigmatism are substantial. Uncorrected astigmatism during early visual development is linked to meridional amblyopia and broader best-corrected visual deficits in some astigmatic subtypes, supporting early detection and correction strategies [10–12]. In modern learning environments, visually intensive tasks and screen exposure further emphasize the need for accurate refractive correction in school-going children and adolescents [6,8]. Because oblique axes are strongly orientation-specific, they deserve explicit attention in screening programs and in routine refraction reporting.

Epidemiological studies across regions report astigmatism prevalence and axis distributions that vary with ethnicity, age composition, and study design (population-based versus clinic-based) [1–3]. Moreover, bilateral astigmatism shows patterned relationships between fellow-eye axes, including rule similarity and symmetry patterns, which can increase the likelihood of bilateral oblique presentations and guide counseling regarding follow-up [4,5]. Axis documentation also supports longitudinal comparison as astigmatism evolves with growth and aging.

Despite extensive literature from several regions, detailed OPD-based descriptions of oblique and bilateral oblique patterns in Indian young populations are limited. Such profiling is useful for planning school screening referrals, optimizing refraction workflows, and anticipating the need for cylindrical correction, including toric spectacles or contact lenses. A clear understanding of axis clusters also helps clinicians counsel patients about expected visual quality and adaptation.

The present study was conducted in a tertiary-care outpatient setting serving a mixed urban–rural catchment area to characterize the spectrum of astigmatism in young individuals. Objectives of the study were: (i) to determine the distribution of WTR, ATR, oblique and bi-oblique astigmatism among astigmatic eyes; (ii) to describe the magnitude and axis-range profile of oblique/bi-oblique astigmatism; and (iii) to examine oblique/bi-oblique astigmatism by laterality, age group, gender, and eye involved.

## METHODOLOGY

### Study Design, Period, and Setting

This investigation was conducted as a hospital-based cross-sectional descriptive study over a period of three months, from June 2025 to August 2025, in the Ophthalmology Outpatient Department of Government General Hospital, Srikakulam (SKLM), Andhra Pradesh, India, where consecutive patients attending the outpatient services during the study period were evaluated to describe the clinical and epidemiological characteristics relevant to the study objectives within a real-world tertiary care setting.

**Study population:** Consecutive patients aged 4–40 years presenting to the OPD and found to have astigmatism on refraction were included. Each participant contributed data from both eyes, yielding 700 eyes from 350 patients. The sample size reflected the number of eligible attendees during the defined period.

**Inclusion criteria:** Age 4–40 years; astigmatism defined as cylindrical error ≥0.50 diopters (D) in either eye on refraction; consent to participate.

**Exclusion criteria:** History of ocular trauma or surgery; corneal ectasia, active ocular surface disease, or visually significant cataract; manifest strabismus or nystagmus interfering with reliable refraction; and retinal or optic nerve pathology affecting best-corrected vision.

**Clinical evaluation and refraction protocol:** All participants underwent unaided and best-corrected visual acuity assessment, slit-lamp biomicroscopy, and fundus evaluation. Objective refraction was obtained using an autorefractometer and refined by streak retinoscopy. Subjective Verification was performed in all the participants. In children, cycloplegic refraction was used as part of routine pediatric evaluation to reduce accommodative influence [6,12]. Cylinder power and axis were recorded in minus-cylinder notation, and the final accepted refraction was documented.

### Classification of Astigmatism

Astigmatism was classified based on the minus cylinder axis orientation during subjective verification using standard axis conventions [6,10]. Based on the cylindrical axis, astigmatism was categorized into with-the-rule (WTR), against-the-rule (ATR), and oblique astigmatism [6,10].

With-the-rule (WTR) astigmatism was defined as minus cylinder with the axis positioned between 0°–30° or 150°–180° [6,10].
Against-the-rule (ATR) astigmatism was defined as minus cylinder with the axis positioned between 60°–120°. [6,10].

Oblique astigmatism was defined as minus cylinder with the axis positioned outside the principal meridians, specifically between 31°–59° or 121°–149° but at right angles to each other. [6,10].

Bi-oblique astigmatism was operationally defined as the two principal axes not at right angles to each other. [4,5].

**Outcome measures:** Primary outcomes included (i) eye-wise distribution of astigmatism types (WTR/ATR/oblique/bi-oblique) and (ii) the profile of oblique/bi-oblique astigmatism by cylinder magnitude and axis range. Secondary outcomes included distribution of oblique/bi-oblique astigmatism by laterality, age group, gender, and eye involved.

**Data management and quality control:** Data were entered into a predesigned proforma and cross-checked for completeness. Range checks were applied for cylinder magnitude and axis values. Eyes were analyzed as the unit for type distribution, while patient-level variables were used for demographic summaries.

**Statistical analysis:** Data were summarized using descriptive statistics. Categorical variables are presented as frequency and percentage. Graphs were generated to depict key distributions. The analysis focused on distributional description rather than hypothesis testing.

**Ethical considerations:** The study was conducted in accordance with the principles of the Declaration of Helsinki. Institutional permission was obtained from the hospital administration of Government General Hospital (GGH), Srikakulam (SKLM), Andhra Pradesh, India. Written informed consent (and assent where appropriate) was obtained from all participants prior to enrollment, and strict confidentiality was maintained throughout data collection, analysis, and reporting.

## RESULTS

A total of 350 patients (700 eyes) with astigmatism were evaluated. The largest proportion of participants belonged to the 10–19-year age group, with a near-equal gender distribution. Bilateral astigmatism predominated over unilateral presentation (Table 1).

**Table 1. Demographic profile of the study population (n = 350 patients)**

| Variable | Number | Percentage (%) |
|---|---|---|
| Age group (years) | | |
| 4–9 | 68 | 19.4 |
| 10–19 | 104 | 29.7 |
| 20–29 | 96 | 27.4 |
| 30–40 | 82 | 23.4 |
| Gender | | |
| Male | 182 | 52.0 |
| Female | 168 | 48.0 |
| Laterality | | |
| Unilateral astigmatism | 74 | 21.1 |
| Bilateral astigmatism | 276 | 78.9 |

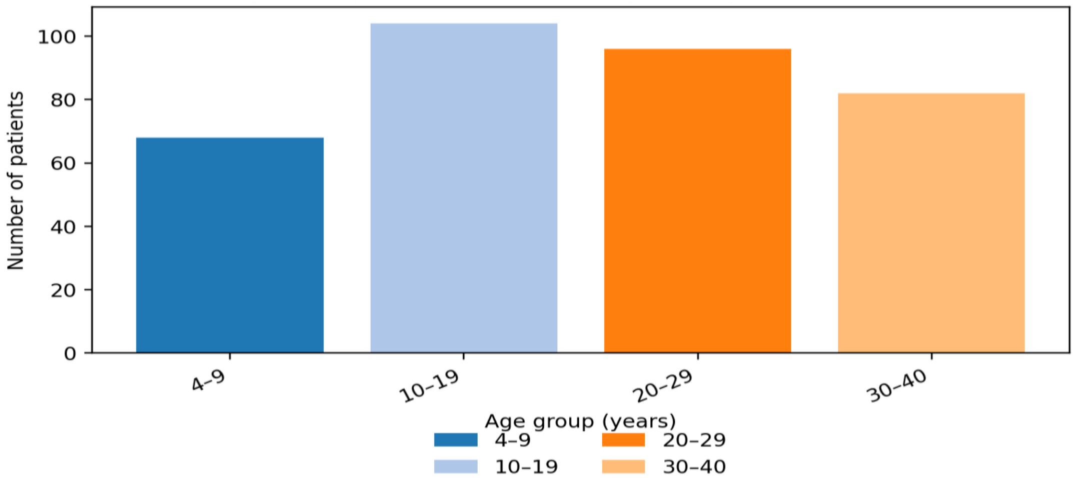


**Figure 1. Age-group distribution of study participants.**

Among 700 eyes, WTR astigmatism constituted the predominant pattern (53.1%), followed by ATR (24.0%). Oblique astigmatism accounted for 17.7% of eyes, while bi-oblique astigmatism contributed 5.1% (Table 2).

**Table 2. Distribution of types of astigmatism among studied eyes (n = 700 eyes)**

| Type of astigmatism | Number of eyes | Percentage (%) |
|---|---|---|
| With-the-Rule (WTR) | 372 | 53.1 |
| Against-the-Rule (ATR) | 168 | 24.0 |
| Oblique astigmatism | 124 | 17.7 |
| Bi-oblique astigmatism | 36 | 5.1 |
| Total | 700 | 100.0 |

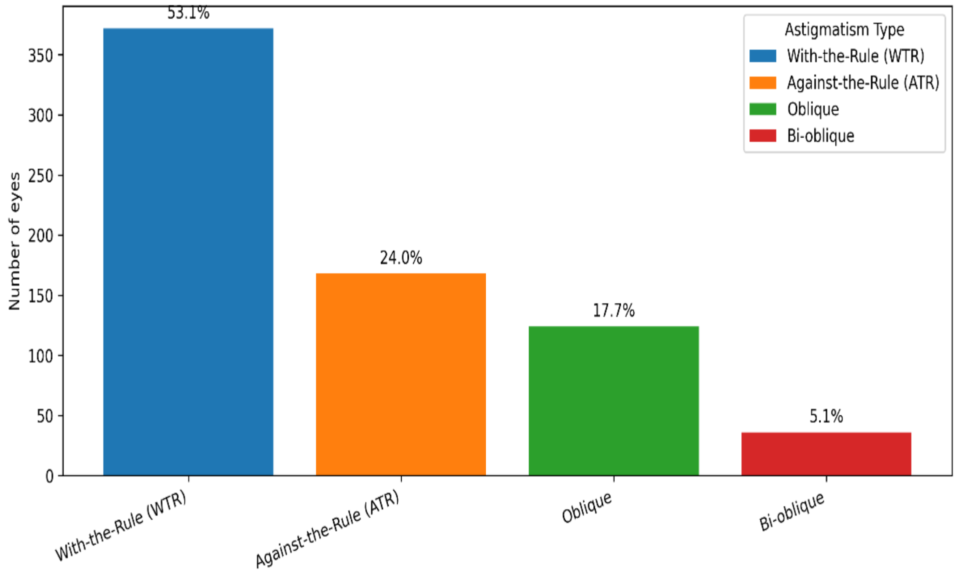


**Figure 2. Distribution of astigmatism types among eyes.**

A focused analysis of oblique and bi-oblique astigmatism included 160 eyes. Oblique astigmatism comprised 77.5% of these eyes, whereas bi-oblique astigmatism constituted 22.5%. Most cylinders were mild (0.50–1.00 D; 48.8%) or moderate (>1.00–2.00 D; 38.7%), and only 12.5% had cylinder power >2.00 D. Axis clustering was observed mainly within 120°–150° (45.0%) and 30°–60° (40.0%) ranges (Table 3).

**Table 3. Characteristics of oblique and bi-oblique astigmatism (n = 160 eyes)**

| Parameter | Number of eyes | Percentage (%) |
|---|---|---|
| Type | | |
| Oblique astigmatism | 124 | 77.5 |
| Bi-oblique astigmatism | 36 | 22.5 |
| Cylinder power (D) | | |
| 0.50–1.00 D | 78 | 48.8 |
| >1.00 D to 2.00 D | 62 | 38.7 |
| >2.00 D | 20 | 12.5 |
| Axis range | | |
| 31°–59° | 64 | 40.0 |
| 121°–149° | 72 | 45.0 |
| Other oblique axes | 24 | 15.0 |

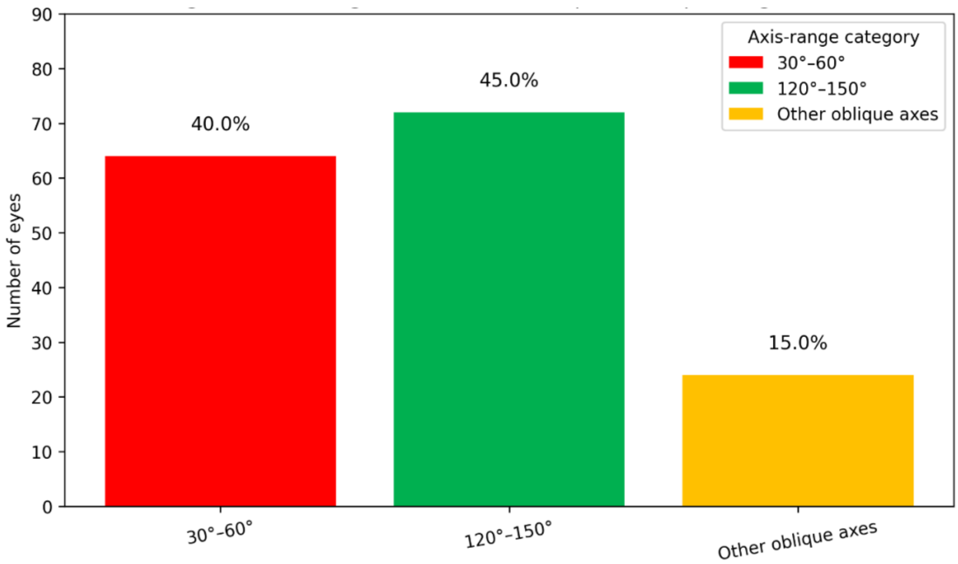


**Figure 3. Axis-range distribution in oblique/bi-oblique astigmatism.**

Eye-wise distribution of oblique/bi-oblique astigmatism was balanced (right eye 51.3%, left eye 48.7%). Males contributed 53.8% of oblique/bi-oblique eyes. The 10–19-year age group accounted for the largest share of oblique/bi-oblique eyes (33.8%), followed by 20–29 years (30.0%) (Table 4).

**Table 4. Eye-wise and gender distribution of oblique astigmatism (n = 160 eyes)**

| Variable | Number of eyes | Percentage (%) |
|---|---|---|
| Eye involved | | |
| Right eye | 82 | 51.3 |
| Left eye | 78 | 48.7 |
| Gender | | |
| Male | 86 | 53.8 |
| Female | 74 | 46.2 |
| Age group distribution of oblique/bi-oblique eyes | | |
| <10 years | 22 | 13.8 |
| 10–19 years | 54 | 33.8 |
| 20–29 years | 48 | 30.0 |
| 30–40 years | 36 | 22.5 |

**DISCUSSION**

This hospital-based study profiled astigmatism patterns in a young cohort (4–40 years) and demonstrated a clear predominance of WTR astigmatism, followed by ATR. This pattern mirrors observations from several epidemiologic and clinic-based studies in younger age groups, where WTR is common and ATR becomes more prominent only later in life [11-14]. The high proportion of bilateral astigmatism in our sample also aligns with evidence that astigmatic axes across fellow eyes are not independent and often exhibit rule similarity and symmetry patterns [4,5].

Compared with population surveys, clinic-based series often show higher proportions of clinically relevant refractive errors because symptomatic individuals and those seeking spectacles are over-represented. Accordingly, the present distributions should be interpreted as an OPD profile rather than prevalence. Even within this context, the strong WTR dominance supports routine emphasis on cylindrical detection in children and adolescents, where small cylinders can meaningfully affect near work and classroom performance.

A major finding was the substantial burden of oblique-related astigmatism (oblique plus bi-oblique), accounting for nearly one-quarter of astigmatic eyes. Oblique axes deserve emphasis because they can produce greater functional impairment than equivalent cylinder powers at the cardinal axes. Reviews and experimental work indicate that axis orientation influences the severity of blur, visual acuity degradation, and task performance [6–10]. In particular, induced oblique astigmatism during computer viewing is associated with increased symptoms and reduced reading performance, supporting the clinical relevance of axis-specific correction in visually demanding settings [8].

Within the **oblique and bi-oblique astigmatism subgroups,** the majority of cylindrical errors were of **mild to moderate magnitude**. The cylindrical axes showed a clear clustering within the predefined oblique ranges of **31°–59° and 121°–149°.** This pattern is consistent with standard oblique-axis classification and supports the concept of **inter-ocular**

**symmetry,** wherein bilaterally affected individuals tend to attract oblique axes into corresponding paired oblique quadrants of the two eyes. [4,5]. The highest distribution of oblique/bi-oblique eyes in adolescents (10–19 years) is noteworthy, as this period combines ongoing ocular changes with intense educational visual demands. Mild-to-moderate cylinders in this age group are well suited for spectacle correction, and clear axis communication improves adaptation.

Astigmatism is also important in pediatric visual development. Uncorrected astigmatism in early childhood is associated with meridional amblyopia and with reductions in best-corrected acuity in certain astigmatic subtypes, emphasizing the importance of early detection and reliable correction [10–12]. Although the present study did not quantify amblyopia or meridional acuity, the observed proportion of oblique axes supports targeted screening and prompt spectacle correction, particularly in younger children and school-going adolescents. Where available, periodic refraction review helps ensure axis stability and appropriate updating of prescriptions.

Longitudinal evidence confirms that astigmatism is dynamic across time and that a shift toward ATR becomes more frequent with age, even when WTR predominates in youth [13,14]. Therefore, documenting axis orientation, not only cylinder magnitude, is valuable for follow-up planning and counseling. In tertiary OPD settings, structured refraction with axis-specific documentation can support early intervention, reinforce compliance, and guide anticipatory counseling regarding stability and expected axis shifts [6,13,14].

**Limitations**

This hospital-based, cross-sectional analysis reflects an OPD-attending population rather than community prevalence. The short 3-month study window and consecutive enrollment introduce selection effects linked to healthcare-seeking behavior. Corneal topography and vector analysis were not performed for all participants, limiting etiologic attribution and detailed axis analytics. Functional outcomes such as meridional acuity, amblyopia status, spectacle adherence, and socioeconomic barriers were not assessed.

## CONCLUSION

In young patients attending a tertiary-care ophthalmology outpatient department, with-the-rule astigmatism emerged as the most prevalent pattern, followed by against-the-rule astigmatism. Oblique and bi-oblique astigmatism together accounted for nearly one-quarter of astigmatic eyes, with the majority of cylindrical errors falling within the mild-to-moderate range. The distribution of oblique axes showed clear clustering within the 31°–59° and 121°–149° ranges, and adolescents contributed the largest proportion of eyes with oblique-related astigmatism.

Given the recognized functional implications of oblique astigmatism for visual performance and visual development, routine axis-specific screening, precise refractive assessment, and timely optical correction, particularly in children and school-going adolescents, should be systematically incorporated into outpatient workflows and school- and community-based eye-care programs. Future studies incorporating corneal topography and age-appropriate functional visual assessments may further enhance risk stratification and inform targeted service planning.

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