

## Rule Similarity and Axis Symmetry Patterns in Young Patients with Bilateral Astigmatism

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### Abstract

**Objective:** To report rule similarity and axis symmetry patterns in young subjects with bilateral astigmatism.

**Methods:** The cross-sectional study was conducted at Al-Shifa Trust Eye Hospital, Rawalpindi, Pakistan, from October 1, 2018, to March 31, 2019, and comprised diagnosed cases of bilateral astigmatism of either gender aged 15–45 years. After giving detailed ophthalmic history, all the participants underwent autorefractometry followed by subjective refraction. Based on refractive status, rule similarity was categorised as isorule or anisorule, while axis symmetry was categorised as direct or mirror. Data was analysed using SPSS 20.

**Results:** Of the 204 participants, 128(62.7%) were males and 76(37.3%) were females. The overall mean age was 26.64±8.44 years. Isorule astigmatism was present in 169(82.8%) participants, while 125(61.3%) had a mirror pattern of axis symmetry. Under the mirror and direct symmetry models, the medians of absolute difference in the axis of fellow eyes were 10 and 5 degrees respectively from exact symmetry. No significant association of rule similarity or symmetry of axis was found with age or gender ( $p>0.05$ ), while significant association was found between rule similarity and type of astigmatism ( $p<0.001$ ).

**Conclusions:** Bilateral astigmatism of isorule category was found in majority of the participants, while mirror symmetry of the axis was more common than direct symmetry.

**Keywords:** Astigmatism, Axis, Refractive errors, Rule similarity, Symmetry. (JPMA 72: 42; 2022)

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### Introduction

Identification and correction of undiagnosed refractive errors was recognised as one of the priority areas in Vision 2020 programme by the World Health Organisation (WHO) since refractive errors account for 43% of visual impairment globally.<sup>1</sup> Astigmatism has been reported as the most common refractive error both in children and adults.<sup>2</sup> Literally, astigmatism is derived from two Greek words, 'a' and 'stigma', meaning 'absent' and 'point' respectively.<sup>3</sup> It is a type of refractive error where parallel rays of light from an object at infinity pass through the ocular media, forming two or more focal lines instead of a point focus as a result of unequal refraction in different meridians, ultimately leading to blurred vision.<sup>4</sup> The cause of this error in refraction may be unequal curvatures of cornea or crystalline lens, decentration or tilt in the lens, varying refractive indices across the crystalline lens, or alterations in the posterior pole geometry.<sup>5</sup> In addition to blurred vision, patients may present with complaints of asthenopia, eyestrain, headache and difficulty in night-time driving.<sup>6</sup> Regarding the aetiology, age, gender, genetics and environmental factors can cause astigmatism, while its

prevalence varies in different parts of the world.<sup>7</sup> The prevalence of astigmatism among adults with refractive errors in Pakistan was reported to be 37%.<sup>8</sup>

According to focal line position, an unaccommodated astigmatic eye can be classified into five categories: simple hypermetropic astigmatism (SHA), compound hypermetropic astigmatism (CHA), simple myopic astigmatism (SMA), compound myopic astigmatism (CMA) and mixed astigmatism (MA).<sup>9</sup> Astigmatism is also classified as 'regular', when the two principal meridians are 90 degrees apart, and 'irregular', in which principal meridians are not 90 degrees apart. Regular, or direct, astigmatism is further classified as 'with-the-rule' (WTR), if the refractive power of the vertical meridian is the greatest, and 'against-the-rule' (ATR), when refractive power of horizontal meridian is the greatest, while 'oblique astigmatism' (OA) is the type where the axis of greatest power is neither horizontal nor vertical.<sup>9</sup>

Regarding rule similarity, astigmatism is said to be 'isorule', if both eyes have identical type of regular astigmatism, such as WTR astigmatism in both eyes, and 'anisorule', where both eyes have different types of astigmatism, like WTR in one eye and ATR astigmatism in the fellow eye.<sup>9</sup> Finally, symmetry patterns of axis is classified as 'direct' if the axis of cylinder in both eyes is the same or nearly the same, like having 90 degrees in both eyes, or 'mirror', if the axis of cylinder in both eyes are mirror of each other and

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their sum is equal to 180, like having 105 degrees in one eye and 75 degrees in the fellow eye.<sup>10</sup>

Studies conducted on refractive errors in the local population have mostly determined the prevalence of myopia, hypermetropia, astigmatism and types of astigmatism, but patterns of rule similarity or symmetry of axis in cases with bilateral astigmatism have not been described. In actual clinical practice, description of rule similarity and axis symmetry pattern is also important in addition to determining the type of astigmatism.<sup>11</sup> For example, if isorule pattern is established as the predominant pattern in a population, the possibility of some acquired corneal disorder might be suspected if a patient with anisorule astigmatism or a large inter-ocular axis difference is encountered in clinical practice. Apart from its clinical importance, such information is helpful in understanding the aetiology of astigmatism and any possible effects related to age, gender, environment, inheritance and race.<sup>11</sup> Longitudinal and real-world studies describing pattern of astigmatism have also been recommended to inform the potential need for any simultaneous astigmatic corrections required during surgical procedures.<sup>12</sup> The current study was planned to determine patterns of rule similarity and axis symmetry in young participants with bilateral astigmatism.

## Patients and Methods

The cross-sectional study was conducted at the general outpatient department (OPD) of Al-Shifa Trust Eye Hospital, Rawalpindi, Pakistan, from October 1, 2018, to March 31, 2019. After approval from the institutional ethics review committee as well as from the Pakistan Institute of Ophthalmology, the sample size was calculated using an online calculator<sup>13</sup> with margin of error 5.2%, confidence interval (CI) 95%, estimated population size >1 million, and prevalence of isorule astigmatism 82.9%.<sup>11</sup>

The sample was raised using non-probability purposive technique from among subjects of either gender aged 15-45 years, requiring a cylindrical correction of at least 0.5 diopters cylinders (DC) in both eyes. Those with ocular diseases that could induce refractive changes, like keratoconus, pterygium, corneal scar, and ectopia lentis, or with a history of ocular trauma or surgery were excluded. After taking informed consent, detailed ophthalmic history was taken from all the participants, who then underwent autorefractometry and keratometry on autorefractometer (NR-5500, Nikon Corporation, Tokyo, Japan) followed by subjective refraction to record best corrected visual acuity (BCVA). Axis and power of the cylinder were further refined using a Jackson cross cylinder. Unit for recording spherical power was diopters (D), while cylindrical power was noted

as DC along with its axis. The participants were dilated with tropicamide 1% (Mydracyl) eye drops for a general eye examination and dilated funduscopy with Volk non-contact super field lens. Participants with a keratometry readings >46D were further evaluated on pantacam (Oculus, Germany) to rule out the presence of keratoconus, which was diagnosed using Belin/Ambrosio Deviation Display and Index of Vertical Asymmetry, and cases were excluded if the condition was found present.<sup>14</sup>

Astigmatism with minus axes at  $90\pm 30$  degrees was considered ATR,  $180\pm 30$  degrees WTR, and the rest were taken as OA. Rule similarity was categorised as isorule if the orientation of cylindrical correction in fellow eyes was the same, and anisorule if they were different. Axis of astigmatism was categorised as direct if both eyes had same axis, and mirror if axes of both eyes were mirror image of each other. For a direct symmetry model, absolute difference in the astigmatic axis of fellow eyes was calculated as: Axis R - Axis L, where R and L denoted right and left eyes respectively. For a mirror symmetry model, the difference in axis was calculated as: Axis R - (180 - Axis L).

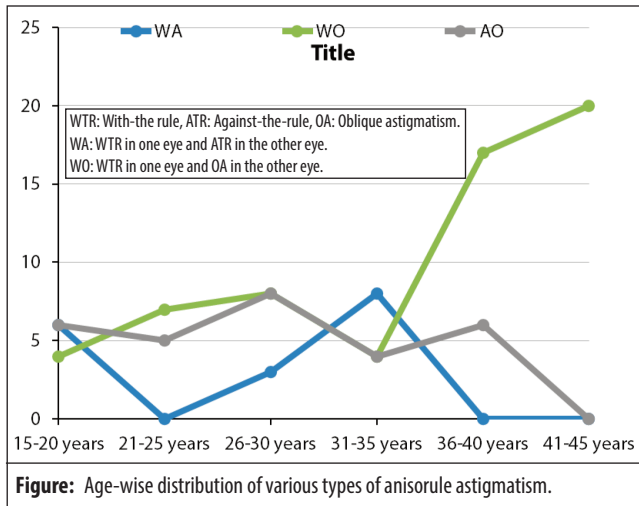
Data was recorded on a predesigned proforma and it was analysed using SPSS 20. Mean values and standard deviations were calculated for numerical variables, while frequencies and percentages were calculated for descriptive variables. Association of rule similarity and symmetry pattern of axis with age and gender was calculated using chi-square test. The level of significance was set as  $p < 0.05$ .

## Results

Of the 204 participants, 128(62.7%) were males and 76(37.3%) were females. The overall mean age was  $26.64\pm 8.44$  years. Mean corneal astigmatism in the right was  $1.47\pm 0.89$  DC (range: 0.00-5.25DC), and 187(91.6%) participants had corneal astigmatism up to 2.50DC. In left eye, mean corneal astigmatism was  $1.49\pm 0.92$  DC (range: 0.00-5.25 DC), and 192(94.12%) participants had corneal astigmatism up to 2.75DC. The mean spherical errors for right and left eyes were  $1.34\pm 1.63$ D and  $1.37\pm 1.61$ D respectively. The mean cylindrical errors for right and left eyes were  $1.12\pm 0.76$ DC and  $1.12\pm 0.80$ DC.

The most common type of astigmatism in 408 eyes was WTR 242(59.3%), followed by ATR 130(31.9%) and OA 36(8.8%). The most common refractive type of astigmatism was CMA 238(58.3%) and the least common was SHA 8(2%).

Isorule astigmatism was the dominant type in 169(82.8%) participants and anisorule astigmatism was found in



**Table-1:** Relationship of rule similarity with different variables.

Independent variables	Isoreule n (%)	Anisoreule n (%)	p-value
<b>Gender</b>			0.451
Male	108 (84.4)	20 (15.6)	
Female	61 (80.3)	15 (19.7)	
<b>Age (years)</b>			0.487
15-30	121 (84.0)	23 (16.0)	
31-45	48 (80.0)	12 (20.0)	
<b>Symmetry pattern</b>			0.175
Direct	69 (87.3)	10 (12.7)	
Mirror	100 (80.0)	25 (20.0)	
<b>Type of Astigmatism (Right Eye)</b>			<0.001
WTR	109 (93.2)	8 (6.8)	
ATR	56 (87.5)	8 (12.5)	
OA	4 (17.4)	19 (82.6)	
<b>Type of Astigmatism (Left Eye)</b>			<0.001
WTR	109 (87.2)	16 (12.8)	
ATR	56 (84.8)	10 (15.2)	
OA	4 (30.8)	9 (69.2)	

35(17.2%). Age-wise distribution of various types of anisoreule astigmatism was noted separately (Figure). No significant association was found between rule similarity and gender, age and symmetry pattern of axis ( $p>0.05$ ). However, significant association was found between rule similarity and type of astigmatism in both eyes ( $p<0.001$ ) (Table 1).

Regarding patterns of axis symmetry, 125(61.3%) participants had mirror axis, while direct axis was found in 79(39.7%). Moreover, 44(68.8%) cases with mirror symmetry and 66(83.5%) with direct symmetry were within  $\pm 15$  degrees of exact symmetry. There was no significant association of age, gender, rule similarity and type of astigmatism in both eyes with symmetry pattern of axis ( $p>0.05$ ) (Table 2).

**Table-2:** Relationship of axis symmetry with different variables.

Independent variables	Direct pattern n (%)	Mirror pattern n (%)	p-value
<b>Gender</b>			0.445
Male	47 (36.7)	81 (63.3)	
Female	32 (42.1)	44 (57.9)	
<b>Age (years)</b>			0.809
15-30	55 (38.2)	89 (61.8)	
31-45	24 (40.0)	36 (60.0)	
<b>Rule similarity</b>			0.175
Isoreule	69 (87.3)	10 (12.7)	
Anisoreule	100 (80.0)	25 (20.0)	
<b>Type of Astigmatism (Right Eye)</b>			0.151
WTR	52 (44.4)	65 (55.6)	
ATR	20 (31.2)	44 (68.8)	
OA	7 (30.4)	16 (69.6)	
<b>Type of Astigmatism (Left Eye)</b>			0.081
WTR	56 (44.8)	69 (55.2)	
ATR	19 (28.8)	47 (71.2)	
OA	4 (30.8)	9 (69.2)	

**Table-3:** Multivariate regression analysis of association between direct and mirror patterns and other factors.

Variables	Odds Ratio	95% CI [Upper, Lower]	p-value
<b>Age</b>	0.993	[0.959, 1.028]	0.676
<b>Gender</b>	1.342	[0.742, 2.427]	0.330
Spherical error (RE)	0.803	[0.573, 1.125]	0.203
Cylindrical error (RE)	0.747	[0.422, 1.323]	0.317
Spherical error (LE)	1.291	[0.901, 1.851]	0.164
Cylindrical error (LE)	0.989	[0.551, 1.776]	0.971

There was no significant impact of age, gender, spherical and cylindrical errors with respect to direct and mirror patterns (Table 3).

### Discussion

The most common type of astigmatism found in the current study was WTR, followed by ATR. Similar results were found in a previous study.<sup>4</sup> Isoreule astigmatism was found in 82.8% participants and only 17.2% participants had anisoreule astigmatism. Similar results were reported in another study.<sup>11</sup> No significant association was found between rule similarity and gender or age in the current study. A study also reported that prevalence of isoreule astigmatism was similar in men and women ( $p=0.44$ ).<sup>11</sup> A study has reported that prevalence of refractive astigmatism remains relatively stable till age 50 at which time there is a trend towards decreasing WTR astigmatism and increasing ATR in the elderly age group.<sup>15</sup> Since the current study did not include participants aged  $>45$ , this relationship of astigmatism with advancing age could not be explored.

In the current study, 60.3% participants showed mirror symmetry and 39.7% had direct symmetry pattern of the

axis. These results are also in agreement with earlier results.<sup>11</sup> The difference between the the current study and the one by Asharlous et al. is the sample size.<sup>11</sup> The current study had a relatively smaller sample size as it was conducted during a period of 6 months in only one tertiary care hospital, while the other study was done 160,608 patients who were examined at 4 different eye clinics in Tehran, Iran.<sup>11</sup> In order to generalise the results of tat hospital-based study, another population-based study in Iran was conducted by the same set of researchers which also reported mirror symmetry as the predominant pattern.<sup>16</sup> Since Iran is a neighbouring country of Pakistan, it could be inferred that the population of both countries share some common patterns of astigmatism as shown by the comparable results of both the studies.

Another study with a larger sample size also reported mirror symmetry as the predominant pattern.<sup>17</sup> A study in 1997, however, reported that neither direct nor mirror symmetry was the predominant pattern of bilateral symmetry.<sup>18</sup> A plausible explanation of this difference in symmetry pattern could be smaller sample size of 192 participants in the study by McKendrick et al.<sup>18</sup> Second explanation could be the ethnic differences from the sample of current study, as suggested by another study comparing astigmatism in two ethnic groups.<sup>19</sup> Studies have proposed that Asians have relatively narrower palpebral fissures and tighter eyelids, leading to different astigmatic changes.<sup>15</sup>

Under the mirror symmetry model, the median of absolute difference in the astigmatic axis of fellow eyes reported in the current study was 10 degrees from exact symmetry. Regarding the direct symmetry model, the median of difference in the astigmatic axis of fellow eyes was 5 degrees. Two previous studies showed that this difference was 10 degrees and 20 degrees under mirror and direct symmetry models respectively.<sup>11,17</sup> The current study reported that 68.8% cases with mirror symmetry and 83.5% with direct symmetry were within  $\pm 15$  degrees of exact symmetry. In contrast, a study reported 68% of cases with mirror symmetry and 47.1% with direct symmetry within  $\pm 15$  degrees of exact symmetry.<sup>11</sup> Hence, the finding of the current study was that although mirror pattern was more common compared to direct pattern, the axes in direct pattern showed better symmetry than the mirror pattern. This finding is contrary to the findings of the Iranian study.<sup>11</sup> These differences between the symmetry patterns could possibly be explained due to difference in age ranges in the two studies. The age range in the current study was 15-45 years and older age group was excluded to avoid any effects on astigmatism related to age-related conditions. Contrary to this, the sample in the study of Asharlous et

al.<sup>11</sup> had a wider age range of 10-80 years which could affect the results due to development of acquired changes with age, like corneal degenerations and senile lens changes. So, although mirror axis was the predominant pattern of symmetry, the transitional changes with advancing age could affect the symmetry distribution. Studies suggest that increasing age is associated with a shift toward ATR astigmatism.<sup>14,20</sup> Another possible explanation could be the difference in clinical assessment methods. The methodology adopted by Asharlous et al.<sup>11</sup> did not include the use of cross cylinder for refining of cylinder axis, which was a part of refraction protocol in the current study. Finally, the current study excluded cases with history of extraocular surgery, like strabismus surgery, as surgical displacement of extraocular muscles could also induce changes in ocular axis, while this condition was not considered in the exclusion criteria set by Asharlous et al.<sup>21</sup>

To the best of our knowledge, the current study is the first one conducted in Pakistan to determine the rule similarity and axis symmetry patterns in cases with bilateral astigmatism. Since this was a hospital-based study, it was possible to exclude the cases that had some secondary pathologies leading to astigmatism, like early keratoconus, by using other investigations. Such pathologies are likely to be missed in community-based studies due to larger sample sizes and lack of availability of additional investigations. Use of cross cylinder for refinement of axis also ensured accurate calculation and improved reliability of subjective refraction. The major limitation of the current study was a relatively smaller sample size which means that further studies with larger sample sizes and multi-centre involvement are recommended to validate the results. Moreover, the current study did not include the older age group which could have affected the results.

## Conclusion

Bilateral astigmatism was found as isorule in majority of the participants, while mirror symmetry of axis was more common than direct symmetry. These results are mostly comparable with the findings of previous studies conducted in this region of world.

**Disclaimer:** The text is based on a BSc Honours thesis submitted at the University of Health Sciences, Lahore.

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