Original Article

Relative Distribution and Amount of Different Types of Astigmatism in Mixed Ethnic Population of Karachi

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Purpose: Astigmatism is a common refractive problem and is especially significant in children because of its effect on visual development. In this article we have analysed relative distribution of different types and amount of astigmatism in the mixed ethnic population of Karachi.

Material and Methods: Records of 914 eyes with astigmatic error in a clinic based set up were analysed retrospectively. Streak retinoscope was used for refraction and sphero cylindrical method was used to minutely neutralize the reflex. Half diopter cross cylinder was used to verify and refine the power and axis of cylindrical lens. Any error, stigmatic (spherical) or astigmatic (cylindrical) of ¼ diopter or more was considered an error and included in the analysis.

Result: Astigmatic error was present in 914 of the 1898 eyes with ametropia (48.16%). Of the 914 eyes with astigmatism, myopic astigmatism was present in 700 eyes (76.60%), hypermetropic astigmatism in 175 eyes (19.14%), and mixed astigmatism in 39 eyes (4.26%). Of the 914 eyes with astigmatism, mild astigmatism (1/4 to 1 D) was present in 616 eyes (67.40%), moderate astigmatism (>1-2 D) in 247 eyes (27.02%), and high astigmatism (>3 D) in 51eyes (5.58%).

Conclusion: Myopic astigmatism was the major type of astigmatic error found in the mixed ethnic population of Karachi city in the age group from 1 to 40 years. Astigmatism >1 D was found in 32.60% of eyes with astigmatic error.

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In our previous audit of retinoscopic findings[1] we retrospectively analysed the relative distribution of different types of refractive errors in ametropic mixed ethnic population of the metropolitan city of Karachi.

Astigmatism is that form of refractive error wherein parallel rays of light from infinity passing through the optical media form two or more far lines rather than a point focus due to unequal refraction of light in different meridians. It results when one principal meridian of the corneal and/or lenticular surface is flatter than the other or the radii of curvature of the two principal meridians are unequal. In regular astigmatism two principal meridians are perpendicular to each other[2,3].

Depending on the position of the two images (far lines) in relation to the retina, regular astigmatism has been classified as simple, compound and mixed. In 'simple' astigmatism, one meridian is emmetropic; therefore, only one far line is either in front (simple myopic) or behind (simple hypermetropic) the retina. In 'compound' astigmatism, both the far lines are either in front (compound myopic) or behind (compound hypermetropic) the retina. When one far line falls short of the retina and the other falls behind the resulting astigmatic error is called 'mixed'[2,3].

Astigmatism is a common refractive problem. The reported prevalence of this refractive error in children is quite varied, and is influenced by age[4]. In infants, studies have reported prevalence rates as high as 70% for astigmatism of more than 1 dioptre[5]. Other studies have indicated that the prevalence of astigmatism of 1.00 D or more was 25% in children aged 1–48 months and decreased in older children to about 12–13% by the age of 10 years[6]. Mayer also showed that 25% of children with same age group had astigmatism (≥1.00 D)[7]. A study in 570 Chinese children aged 36–65 months reported that 38.6% of the children had an astigmatic error of 0.50 D or more[8]. The prevalence of astigmatism among Chinese (aged 6 to 7 years) in Singapore was 17.1%[9]. Fan et al found astigmatism (≥ 1.00 D) in 21.1% of preschool children (mean age 55.7 months)[10].

Unlike myopia and hypermetropia, astigmatism imposes considerable optical defocus at all viewing distances. The continuous strain imposed on ciliary muscles in a constant struggle to get a sharp focus is a source of considerable asthenopia and eye-strain in astigmatic individuals[11].

Because of immature and developing visual system, astigmatism is especially significant in children. Astigmatism has been implicated in the development of amblyopia and progression of myopia in children. Abrahamsson et al pointed out a relation between astigmatism and the development of meridional amblyopia in children. They analyzed the refraction changes in 310 children with astigmatism greater than or equal to 1.0 D in at least one eye at one year of age; amblyopia was found in 23 of the children (7%) at the age 4 years. They also found that an increasing astigmatism was associated with an increased risk of developing amblyopia[12].

Fulton et al described the relation between increasing myopia and an increase in astigmatism in their study of 298 children aged 0–10 years[13]. In children of all age groups, they found greater myopia in eyes with astigmatism more than 1.00 D. They indicated that astigmatism in children, particularly of higher degrees (≥3 D), might lead to visual perturbations that could trigger development of myopia, similar to that seen in animal models[13,14].

Gwiaza et al also described a relation between astigmatism and the development of myopia in children and proposed the possible mechanism[15]. They regularly followed 245 subjects for a period of 6 to 23 years from infancy and showed that infantile astigmatism was associated with increased astigmatism and myopia during the school years. They proposed two possible mechanisms underlying this association: (a) infantile astigmatism disrupts focusing mechanisms; and (b) ocular growth induces astigmatism and myopia.

Cezipita et al also observed a positive correlation between astigmatism and myopia in 167 subjects with an average age of 24 months ($P < 0.000001$) and concluded that astigmatism predisposes to the progress of myopia[16]. They further analyzed the role of type of astigmatism on myopic progression in same subjects and found a positive correlation between with-the-rule (WTR) astigmatism and myopia; their conclusions were: (a) with-the-rule astigmatism (WTR) predisposes the creation of myopia. (b) against-the-rule (ATR) as well as oblique astigmatism (OLA) has no influence on the creation of myopia[17].

In a more recent article published in British Journal of Ophthalmology, Fan et al not only substantiated this relationship between myopic progression and astigmatism but also suggested that astigmatism was related to longer axial length and axial length growth. However, they found no relationship between myopic progression and the axis of astigmatism[10].

Another problem associated with astigmatism is its relative difficulty in refractive correction leading to poor vision and spectacle intolerance. Garber substantiated this difficulty in school children and provided the evidence of difficulty of correcting high astigmatism in clinical practice, leading to rejection of eye wear in children, with a decrease in classroom performance as a result of unsatisfactory vision[18].

The purpose of this article is to analyse relative distribution of different types and amount of astigmatism in the same population of Karachi.

MATERIALS AND METHODS

We retrospectively analyzed the retinoscopic findings of 1898 ametropic eyes of 962 patients presenting with refractive problems to determine their refractive status. Records of 914 eyes with astigmatic error were further analysed to determine the type and amount of astigmatism. All patients were examined at a private clinic located in a medical complex in the central part of the city where majority of patients belonging to multiple ethnic origins reported from different districts of Karachi. Records of patients seen from January 1984 to December 1991 were included in the analysis.

Refraction was performed objectively on all patients by one of us (KSH) using Streak Retinoscope of Hamblin or Welch Allyn. Sphero-cylindrical method of refraction was used to minutely neutralize the movements (one meridian was neutralized by spherical lens and the perpendicular meridian was neutralized by an appropriate cylindrical lens when required). Subsequently, retinoscopic findings were subjectively verified. Half-diopter cross cylinder was used to verify and refine the axis and power of any cylindrical lens.

A complete adnexal and biomicroscopic anterior segment examination on Haag-Street slit-lamp was performed on all patients. Fundus examination was also performed using Keeler or Welch Allyn Direct Ophthalmoscope. Cycloplegic refraction, after instillation of Atropine eye drops for three days, was performed on all children less than 5 years of age. Older children were refracted 40-50 minutes following topical instillation of 1% Cyclopentolate eye drops twice at 5 to 10 minute interval.

Records of patients with any adnexal, anterior segment and posterior segment pathology were not included in the analysis. Records of patients less than one year and more than forty years were also excluded.

Any astigmatic error of ¼ Diopter or more was considered an error and included in the analysis. For the purpose of this article amount of astigmatism was considered in three grades of ¼ to 1 Diopter, >1 to 3 Diopter, and >3 Diopter.

Compound myopic astigmatism was defined as that needing correction with negative powers in both the meridians, and simple myopic astigmatism was defined as that needing correction with minus cylinder in only one meridian. Compound hypermetropic astigmatism was defined as that needing correction with plus cylinder in both the meridians, and simple hypermetropic astigmatism was defined as that needing correction with plus cylinder in only one meridian. Mixed astigmatism was referred to as refraction needing correction with plus cylinder in one meridian and minus cylinder in the other.

RESULTS

Table 1 summarizes the relative prevalence of stigmatic and astigmatic refractive error in this audit of retinoscopic findings of 1898 eyes with ametropia (Fig. 1). Stigmatic error (myopia and hypermetropia) was present in 984 of the 1898 eyes with ametropia (52.84%) while astigmatic error (myopic, hypermetropic, and mixed astigmatism) was present in 914 of the 1898 eyes with ametropia (48.16%).

Table 2 summarizes the relative distribution of myopic, hypermetropic, and mixed astigmatism (Fig. 2). Myopic astigmatism (simple and compound) was the most common type of astigmatic error present in our analysis. Of the 914 eyes with astigmatism, myopic astigmatism was present in 700 eyes (76.60%). Hypermetropic (simple and compound) astigmatism was found in 175 of the 914 eyes with astigmatism (19.14%), while mixed astigmatism was found in only 39 of the 914 eyes with astigmatism (4.26%).

Table 3 summarizes the amount of astigmatism in 914 astigmatic eyes (Fig. 3). Mild astigmatism (1/4 to 1 Diopter) was present in 616 of the 914 eyes with astigmatism. Two hundred and forty-seven of the 914

eyes with astigmatism (27.02%) had moderate astigmatism of 1 to 3 Diopters. Astigmatism of >3 Diopters was present in only 51 of the 914 eyes with astigmatism (05.58%).

Table 4 summarizes the amount of astigmatism in 700 eyes with myopic astigmatism (Fig. 4). Mild astigmatism (1/4 to 1 Diopter) was present in 496 of the 700 eyes with myopic astigmatism (70.86%). One hundred and sixty-three of the 700 eyes with myopic astigmatism (23.28%) had moderate astigmatism of 1 to 3 Diopters. Astigmatism of >3 Diopters was present in only 41 of the 700 eyes with myopic astigmatism (05.86%).

Table 5 summarizes the amount of astigmatism in 175 eyes with hypermetropic astigmatic (Fig. 5). Mild astigmatism (1/4 to 1 Diopter) was present in 110 of the 175 eyes with hypermetropic astigmatism (62.86). Sixty-four of the 175 eyes with hypermetropic astigmatism (36.57%) had moderate astigmatism of 1 to 3 Diopters. Astigmatism of >3 Diopters was present in only one of the 175 eyes with hypermetropic astigmatism (0.57%).

Table 6 summarizes the amount of astigmatism in 39 eyes with mixed astigmatism (Fig. 6). Mild astigmatism (1/4 to 1 Diopter) was present in 10 of the 39 eyes with mixed astigmatism (25.64%). Twenty of

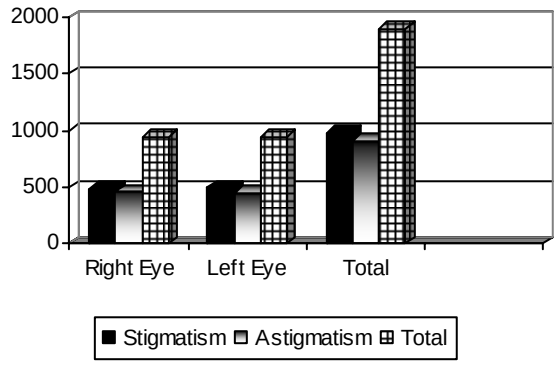

Fig. 1: Relative distribution of stigmatism and astigmatism

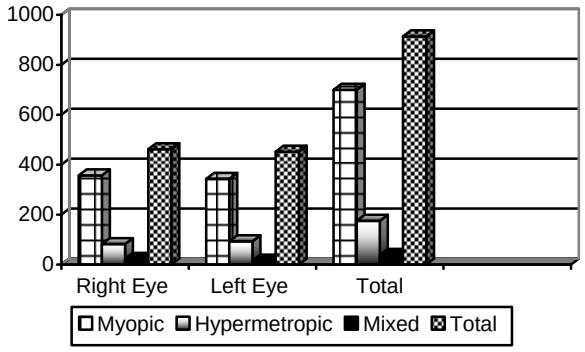

Fig. 2: Relative distribution of myopic, hypermetropic and mixed astigmatism

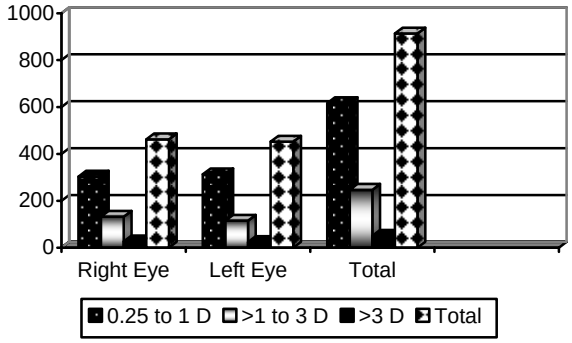

Fig. 3: Amount of astigmatism in 914 astigmatic eyes

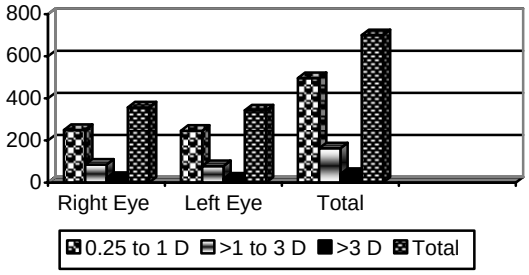

Fig. 4: Amount of astigmatism in 700 eyes with myopic astigmatism

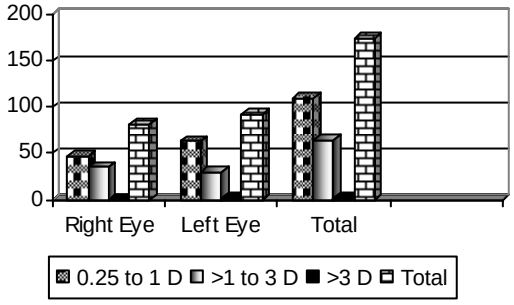

Fig. 5: Amount of astigmatism in 175 eyes with hypermetropic astigmatism

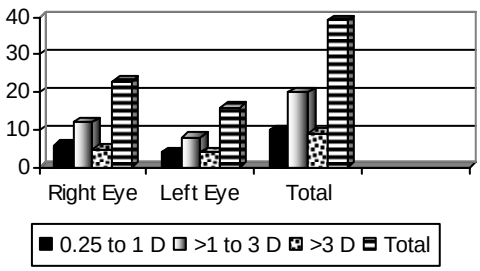

Fig. 6: Amount of astigmatism in 39 eyes with mixed astigmatism

the 39 eyes with mixed astigmatism (51.28%) had moderate astigmatism of 1 to 3 Diopters. Astigmatism of >3 Diopters was present in 9 of the 175 eyes with mixed astigmatism (23.08%).

The World Health Organization has grouped uncorrected refractive error with cataract, macular degeneration, infectious diseases, and vitamin A deficiency among the leading causes of blindness and vision impairment in the world. 'Vision 2020', a global initiative for the elimination of avoidable blindness by the World Health Organization (WHO), also included refractive errors among the five conditions of immediate priority[19]. Astigmatic error becomes more significant due to its high prevalence, its implications on visual development in early years of life, and the relative difficulty in its refractive correction leading to spectacle intolerance and its implications.

Before comparing our results with other surveys, it is important to note differences in the definitions of astigmatism, varying age compositions of the study

DISCUSSION

Table 1: Relative prevalence of stigmatism and astigmatism

Refractive Status	Right Eye n (%)	Left Eye n (%)	Total n (%)
Stigmatism	487 (51.32)	497 (52.37)	984 (52.84)
Astigmatism	462 (48.68)	452 (47.63)	914 (48.16)
Total	949 (100)	949 (100)	1898 (100)

Table 2: Relative distribution of myopic, hypermetropic, and mixed astigmatism

Type of Astigmatism	Right Eye n (%)	Left Eye n (%)	Total n (%)
Myopic	357 (77.27)	343 (75.88)	700 (76.60)
Hypermetropic	82 (17.75)	93 (20.58)	175 (19.14)
Mixed	23 (04.98)	16 (03.54)	39 (04.26)
Total	462 (100)	452 (100)	914 (100)

Table 3: Amount of astigmatism in 914 astigmatic eyes

Amount of Astigmatism	Right Eye n (%)	Left Eye n (%)	Total n (%)
0.25 to1 Diopter	303 (65.59)	313 (69.25)	616 (67.40)
>1 to 3 Diopter	132 (28.57)	115 (25.44)	247 (27.02)
>3 Diopter	27 (5.84)	24 (5.31)	51 (05.58)
Total	462 (100)	452 (100)	914 (100)

Table 4: Amount of astigmatism in 700 eyes with myopic astigmatism

Amount of astigmatism	Right Eye n (%)	Left Eye n (%)	Total n (%)
0.25 to1 Diopter	250 (70.03)	246 (71.72)	496 (70.86)
>1 to 3 Diopter	85 (23.81)	78 (22.74)	163 (23.28)
>3 Diopter	22 (06.16)	19 (05.54)	41 (05.86)
Total	357 (100)	343 (100)	700 (100)

Table 5: Amount of astigmatism in 175 eyes with hypermetropic astigmatism

Amount of astigmatism	Right Eye n (%)	Left Eye n (%)	Total n (%)
0.25 to1 Diopter	47 (57.32)	63 (67.74)	110 (62.86)
>1 to 3 Diopter	35 (42.86)	29 (31.18)	64 (36.57)
>3 Diopter	0 (0.00)	1 (1.08)	1 (0.57)
Total	82 (100)	93 (100)	175 (100)

Table 6: Amount of astigmatism in 39 eyes with mixed astigmatism

Amount of astigmatism	Right Eye n (%)	Left Eye n (%)	Total n (%)
0.25 to1 Diopter	6 (26.09)	4 (25.00)	10 (25.64)
>1 to 2 Diopter	12 (52.17)	8 (50.00)	20 (51.28)
>3 Diopter	5 (21.74)	4 (25.00)	9 (23.08)
Total (%)	23 (100)	16 (100)	39 (100)

population, refractive error measurement techniques and study methodology. Our audit is a clinic-based, retrospective analysis of the record of the retinoscopic findings on patients 1 to 40 years of age who were free from any organic ocular problem.

We used more stringent criteria in defining astigmatism and any cylindrical error of 0.25 Diopter or more was considered an error. Most other studies defined astigmatism as cylinder power of 0.5 or 1.0 Diopter[20-25] except the Brazilian study conducted by Garcia al[26]. Age composition of our studied patients also differed from other surveys which were conducted either on population of limited age group [20-21,24-26] or in a general population comprising all age groups[22].

Our methodology was simple: retionoscopy by sphero-cylinderical method followed by subjective verification and minute refining of cylindrical axis and power by cross-cylinder by a single experienced consultant (KSH) in a clinical set-up. Cycloplegia was used only in children. Most of the recent studies rely on autorefractors with or without cycloplegia. With these limitations we would proceed to compare our results with some interesting studies recently conducted in neighbouring and other countries.

In prevalence survey of 1327 first through eighth grade school children who were members of a Native American tribe in Arizona, USA, the overall prevalence of astigmatism of 1.00 Diopter or more was 42%[20]. In this study noncycloplegic autorefraction was performed with handheld autorefractors.

In prevalence study of 1,024 randomly selected students in the city of Natal, Brazil, 348 students (34.8%) had astigmatism 0.1 Diopter or greater on refractometry. Of 897 participants with ametropia of 0.1 Diopter or more, 348 (38.8%) had astigmatism[26]. In this study, although a more stringent criteria was selected (at least 0.1 Diopter), the overall prevalence and relative proportion of astigmatic error was not as

high as in our study (48.16%) as well as other neighboring and South-East Asian countries.

In a population-based cross-sectional study involving 11,189 adults 30 years of age and older in Bangladesh, astigmatism 0.5 D or more was found in 3625 subjects (32.4%). Of 6370 participants with ametropia, 3625 (56.90%) had astigmatism[21]. Higher overall prevalence and higher relative distribution of astigmatism in this study as compared to ours (56.9% vs 48.16%) may be due to exclusion of all secondary and pathological causes of astigmatic error in our analysis and the entirely different age composition of the populations studied (>30 years vs 1 to 40 years).

In a population-based study involving 4565 individuals 5 years of age and older representing a cross-section of the population of Tehran, Iran, prevalence of astigmatism 0.5 Diopter or more was 50.2% on manifest refraction. Of 2532 participants with ametropia, 1509 (59.6%) had 0.5 Diopter or more astigmatism[22]. High astigmatism defined as manifest cylinder 1.5 Diopter or more was found in 490 (11.1%) of right eyes. Higher overall prevalence and higher relative distribution of astigmatism in this study as compared to ours (56.6% vs 48.16%) may be due to exclusion of all secondary and pathological causes of astigmatic error in our analysis and the entirely different age composition of the population studied (>5 years vs 1 to 40 years).

In a population-based prevalence survey of 1043 adults 21 or more years of age conducted in five rural villages and one provincial town of the Riau Province, Sumatra, Indonesia, astigmatism of 1.00 Diopter or more was found in 193 of 561 (34.40%) ametropic eyes[23]. In this study refraction was performed with handheld autorefractor. We found astigmatism in 48.16% of ametropic eyes but our cut off cylinder power was comparatively low (0.25 Diopter) and our age composition was relatively younger (1-40 years).

In a population-based cross-sectional study involving 1232 Chinese people aged 40 to 79 years in Singapore, astigmatism 0.5 Diopter or more was found in 466 (37.8%) subjects. Of 827 participants with ametropia, 466 (56.35%) had astigmatism[24]. Relative distribution of astigmatic error in this older Chinese population is higher than our younger individuals in spite of our quite low cut off cylinder power of 0.25 Diopter.

In a prevalence survey of 946 students aged 15-19 years from two secondary schools in Singapore, astigmatism >0.5 D was found in 555 subjects (58.7%). Of 841 participants with ametropia, 555 (65.99%) had astigmatism[25]. In this study non-cycloplegic autorefraction was performed with handheld autorefractors. Compared to our results the overall prevalence and relative proportion of astigmatic error is quite high in these Singaporean teenagers in spite of the fact that our cut off cylinder power was quite low (0.25 Diopter).

In spite of our best efforts we failed to find any national study addressing the issue of prevalence of astigmatism or relative distribution of different types and amount of astigmatism in Pakistani population. This would probably be the first analysis of this type on a Pakistani population to be published in Ophthalmic literature. We hope this effort will inspire our colleagues to analyze their record of refraction or organize prevalence survey and present their results.

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