IRBAS www.irbas.academyirmbr.com April-June 2024
International Review of Basic and Applied Sciences Vol. 12 Issue.2

Relation between Different Grades of Pterygium and Amount of Induced Corneal Astigmatism

Dr. MUHAMMAD NAEEM
(Corresponding Author)
Department of Ophthalmology, Lady Reading Hospital MTI Peshawar.
Email: drnaeemps@yahoo.com

SAPNA HABIB
Department of Optometry, Professional College of Medical Sciences, Peshawar.
Ocular Research Centre, Frontier Institute of Ophthalmology (FIO Hospital) Peshawar.

UZMA GHANI
Department of Optometry, Professional College of Medical Sciences, Peshawar.
Ocular Research Centre, Frontier Institute of Ophthalmology (FIO Hospital) Peshawar.

Abstract

A growth of fibrovascular tissue that extends onto the cornea is called pterygium. One of the major issues of patients with pterygium is blurred vision. In advanced cases, impaired vision can occur as a result of pterygium growing directly to cover the pupil. However, in less severe cases, pterygium may also indirectly impair vision through elevated pressure and corneal surface deformation that results in ocular abnormalities. The study aimed to find out the relation of different grades of pterygium with corneal astigmatism. Eyes of 41 patients with unilateral pterygium of different grades were examined. best corrected visual acuity was measured using Snellen visual acuity chart. Sizes of pterygium was evaluated using slit-lamp, (pterygium was graded depending on the extent of corneal involvement) and keratometry was done to find the corneal astigmatism. Pterygium of grade I produces mild astigmatism (1.00 to 2.00 diopters) in 18 patients, grade Ⅱ produces moderate astigmatism (2.00 to 4'00 diopters) in 12 patients. Severs astigmatism (>4.00 diopters) in only 3 patients, common grade of pterygium was grade Ⅰ present in 61% (25) of patients. grade Ⅱ in 31.7% (13) of patients, grade Ⅲ in 7.3% (3) of patients. pterygiums induce 78% (32) of with the- rule astigmatism, 4.9% (2) of oblique astigmatism, 17.1% (7) of against the rule astigmatism. In majority of the patient's common grade of pterygium was grade Ⅱ, and commonly produces mild astigmatism of 1.2D, and the grade increases degree of astigmatism also increases. Pterygium induces with the rule astigmatism and as the corneal involvement increases, degree of astigmatism also increases. Most of the pterygium patients working areas was outdoor and most of them were not using sunglasses or hat.

Keywords: *Pterygium, Astigmatism, Corneal Topography, Visual Acuity.*

Introduction

The ancient Greek words πτερυξ (pteryx) = wing and πτερυγιον (pterygion) = fin are the sources of the word pterygium. A triangular section of the bulbar conjunctiva that invades the cornea, usually from the nasal side and usually within the intrapalpebral fissure, is the characteristic of pterygium. Pterygium was found to be 10.2% common worldwide, with low-lying areas having the highest occurrence. In the tropics and in an equatorial zone between 30° north and south latitudes, there is an increased incidence of

pterygium. Higher occurrence is linked to older age, male sex, outdoor activities, and prolonged sun exposure (ultraviolet light) (Govindasamy S et al., 2022).

In population-based research conducted in rural central India, the prevalence of pterygium rose from 6.7±0.8% in the 30-39 age group to 25.3±2.1% in the 70-79 age group. The frequency of pterygium has been reported in three population-based investigations. The Beijing Eye Study reported a 10-year incidence of pterygium in the adult Chinese population of 4.9%, the Barbados Eye Study reported a 9-year incidence of 11.6% (95% CI,10.1–13.1), and the Bai Chinese population in a rural community reported a 5-year cumulative incidence of 6.8% (95% CI, 5.2-8.4) (Tandon R, et al., 2022).

Astigmatism is significantly increased, and corneal deformation is caused by pterygium. When astigmatism and surface phenomena in pterygium were investigated, it was shown that there was no noticeable visual impairment related with increased astigmatism with the rule (more than 0.5 D in 46%, ≥4 D in 13%) (Parveen S, 2016). Pterygium represents a grave complication that can profoundly affect a child's or an adult's growth, education, and quality of life. Beyond the cosmetic consequences, it can cause astigmatism and corneal irregularities which can worsen eyesight (B, Sohail et al., 2021).

Refraction, keratometry, and corneal topography have all been used to quantify the effect of pterygium on the corneal refractive status. Several factors are suggested to account for the induced astigmatism. One example is tear film pooling near the pterygium's primary edge.(b) Mechanical traction by the pterygium on the cornea .Research indicates that pterygium patients typically experience flattening of the corneal curvature along the horizontal meridian, leading to with-the-rule astigmatism .Pterygium-induced astigmatism, as well as attacks on the visual axis and pterygium-induced restriction of the average rectus muscle, can significantly impair visual acuity and result in blurred vision .Given that the smoothing of the periphery cornea is more significant than that of the central cornea in pterygium, keratometry that solely evaluates the central cornea may yield dubious findings (B, Sohail et al., 2021). In a study conducted at Seoul National University Hospital's Massacre Ophthalmology Department, 59 patients aged 37-81 years were enrolled, with a mean age of 62.1 ± 9.2 years. 45.7% of the patients were men and 54.3% were female. Eyes with pterygium had considerably higher corneal astigmatism (2.07 ± 1.33 DC) compared to normal eyes (0.84 ± 0.47 DC). Pterygium-infested eyes had considerably higher irregularities in the 3- and 5-mm corneal zones (3.67 ± 2.26DC and 5.04 ± 2.72DC, respectively) (Yoon CH et al., 2023).

In Turkey, 47 individuals with pterygium had a mean anterior corneal astigmatism of 2.3 ± 2.3 DC and posterior corneal astigmatism ranging from -0.34 D to -0.30 D. 24 were men and 23 were females, with an average age of 49.4 ± 16.6 (22-80) years. In terms of pterygium morphology, 24 eyes showed a continuous pattern while 23 had a nodular pattern (Gumus K, et al., 2011). In India, 45 individuals with pterygium had a mean corneal astigmatism of 2.1±1.69 D (0.25-7.25), with 23 males and 22 females, with a mean age of 54.58±9.54 (31-65) years. Among these, the relationship between percentage extension and the horizontal length of the pterygium is the most significant, which demonstrated corneal abnormalities (Garg S, et al., 2022).

In a study conducted at Al-Shifa Eye Trust in Rawalpindi, Pakistan, 60 eyes with pterygium were evaluated; 48 (80%) of the eyes belonged to men and 12 (20%) to women. Group A included 37 eyes, or 61.7% of the total number of eyes analyzed. Twenty people (33%) made up group B, whereas just three people (5%) in group C had eyes. In Group A, a pterygium measuring 1.24 ± 0.379 mm was found to induce astigmatism, which was found to be -1.165±0.849 DC. Similarly, in Group B, a pterygium measuring 2.84 ± 0.557 mm was found to induce astigmatism, which was -3.46 ± 1.441 DC. Finally, in Group C, a pterygium measuring 4.83 ± 0.586 mm was found, and astigmatism was induced to be -5.9 ± 0.265 mm (Jaffar S, et al., 2009).

Material and Methods

Study Design

Throughout the study cross sectional study design was used. All the patients were examined on one time examination based study. It was a cross sectional quantitative type.

Study Settings

This study was undertaken in Frontier Institute of Ophthalmology (FIO), Peshawar.

Study Duration

The research study was conducted from September 2023 to March 2024 (6 months).

Sample Size

41 patients calculated by Rao soft calculator on the basis of 5% level of significance and 95% confidence interval.

Sampling Technique

Convenience / Nonprobability sampling technique was applied for this study

Sample Selection

a) Inclusion Criteria

The inclusion criteria of this study was based on two things and are as followed:

- All patients with pterygium will be examined properly for the given purpose.
- All patients regardless of age and gender will be considered.

b) Exclusion Criteria

The exclusion criteria set for this study was as followed:

- Patients who were having any corneal diseases were remained excluded.
- Patients having a history of any eye trauma
- Patients having history of previously done surgery
- Patients wearing contact lenses.

Data collection Procedure

Step by step technical procedure to complete the project was carried as:

a) Informed Consent

Ethical approval was obtained from the ethics committee of Ocular Research Center FIO Hospital Peshawar, Professional College of Medical Sciences, the consent and confidentiality were ensured throughout the study. Details are given below:

b) Demographic Station

First of all personal information section was filled from every patient at a very first station including all information written in the proformas.

c) History Taking Station

An overview was given to each patient about the procedure of examination and asked for their cooperation. Then a detailed history was taken from each participant both systemically and ocularly.

d) Visual Acuity Station

Distance visual acuity (VA) was recorded using distance Snellen charts at 6m distance monocularly and then binocularly. Those patients whose VA was 6/12 or worse was tested further with pinhole to confirm any pathology except pterygium. Improvement with pinhole was considered as refractive error and was correlated with astigmatism.

e) Retinoscopy Station

All those patients who were diagnosed with reduced visual acuity i.e. visual acuity equal or worse than 6/12 associated with pterygium were then passed through proper retinoscopy to find out the possible grade and type of astigmatism consisted with the pterygium.

f) Slit Lamp

All those patients who were having any kind of astigmatism associated with pterygium were then passed under a detailed examination to with the assistance of FIO to exactly confirm the corneal irregularities and grade of astigmatism.

Data Analysis Procedure

SPSS (Statistical package for social sciences) version 20 and MS Excel was used for data analysis. Quantitative data is presented in the form of tables, bar graphs, pie charts etc. Descriptive statistics: mean, median, mode, quartile, coefficient of standard deviation.

Results

Gender and Age Category

Participants of all ages were included and for the purpose of convenience we divided the participants in 07 categories including both males and females. Total of 41 participants were enrolled out of them 24 (58.5%) were males and 17 (41.5%) were females is shown in table 1.

In 1st category 0-10 years there were total of 1 participant in which there was only 01 (2.4%) male, 2nd category 11-20 years (No participants), similarly there were 3 (7.3%) were males and 0 females in 3rd category, 4th category there were 6 (14.6%) were males and 4 (9.8%) were females and so respectively.

Table 1: Gender and Age Category

Demographics		Gender		
		Male n (%)	Female n (%)	Total n (%)
Age category	0-10yrs	1 (2.4)	0 (0)	1 (2.4)
	11-20yrs	0 (0)	0 (0)	0 (0)
	21-30yrs	3 (7.3)	0 (0)	3 (7.3)
	31-40yrs	6 (14.6)	4 (9.8)	10 (24.4)
	41-50yrs	4 (9.8)	3 (7.3)	7 (17.1)
	51-60yrs	5 (12.2)	5 (12.2)	10 (24.4)
	Above 60 yrs	5 (12.2)	5 (12.2)	10 (24.2)
Total		24 (58.5)	17 (41.5)	41 (100)

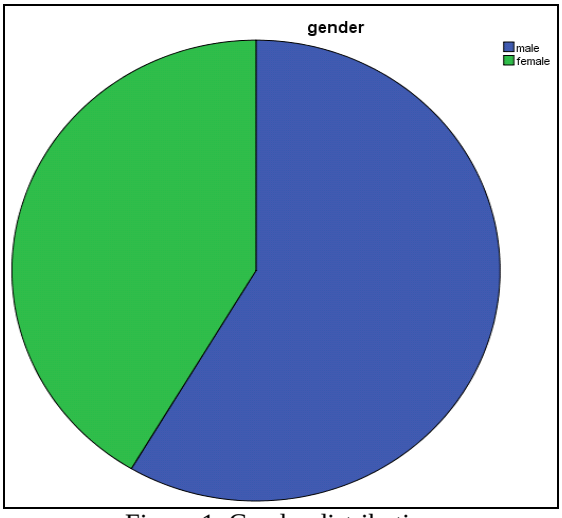

Figure 1: Gender distribution

Gender and Occupations

The result describes a cross tab between gender and occupations. As people from different communities with different occupations were enrolled in which the table 5.2 shows that the whole population enrolled in study was divided into 05 groups based on occupation which includes housewives 14 (34.1%), farmers in which 04 (9.8%) were males and just 01 (2.4%) was female, similarly there were total of 03 (7.3%) were drivers and were males, teachers includes 02 (4.9%) from males and 02 (4.9%) from females and in last group there were all those participants who didn't fit in the above mentioned categories, this category includes students, professors, engineers, businessmen etc and there were 15 (36.6) were males only respectively.

Table 2: Gender and Occupations

Demographics		Gender		
		Male n (%)	Female n (%)	Total n (%)
Occupations	Housewives	00 (0.0)	14 (34.1)	14 (34.1)
	Farmers	04 (9.8)	01 (2.4)	05 (12.2)
	Drivers	03 (7.3)	00 (0.0)	03 (7.3)
	Teachers	02 (4.9)	02 (4.9)	04 99.8)
	Others	15 (36.6)	00 (0.0)	15 (36.6)
Total		24 (58.5)	17 (41.5)	41 (100)

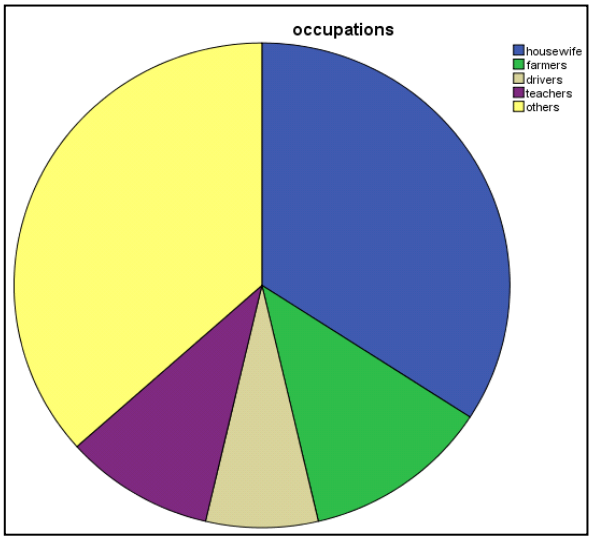

Figure 2: Occupations

Gender and Working Areas of the Participants

The result illustrates the cross tabulation between gender and working areas of the participants. The working area was divided into two i.e. indoor and outdoor. Total of 41 participants 24 (58.5%) were involved in indoor activities in which there were 09 (22.0%) males and 15 (36.6) were female while in outdoor activities there were 15 (36.6%) were males and only 02 (4.9%) were females as described below in table 3.

Table 3: Gender and Working Areas of The Participants

		Gender		
		Male n (%)	**Female n (%)**	**Total n (%)**
Working area	Indoor	09 (22.0)	15 (36.6)	24 (58.5)
	Outdoor	15 (36.6)	02 (4.9)	17 (41.5)

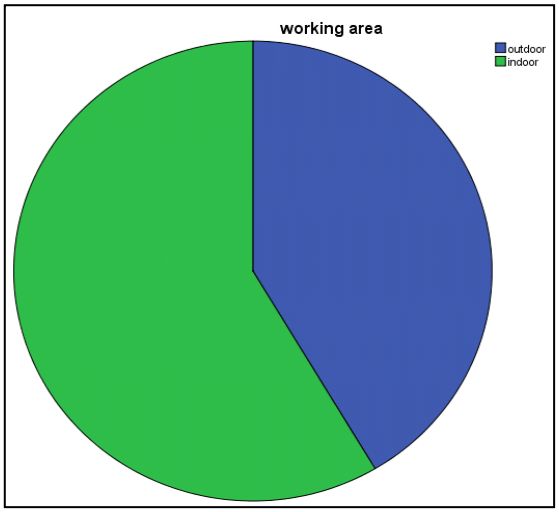

Figure 3: Working Area

Frequency of Pterygium Location

The result shows the frequency and percentage locality of pterygium. Table 4 demonstrate that most of the patients were having pterygium in their nasal side with 32 (76.2%) and less common in temporal region 09 (21.4%) respectively.

Table 4: Frequency of Pterygium Location

	Pterygium location	
	Frequency (n)	**Percentage (%)**
Nasal	32	76.2
Temporal	09	21.4
Total	41	100.0

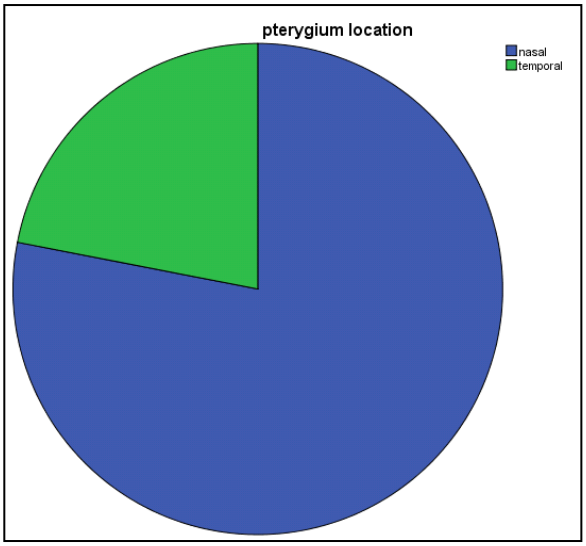

Figure 4: Pterygium Location

Uncorrected Visual Acuity in Association with Pterygium Gender Wise

The result illustrates the drop in visual acuity noticed in patients having pterygium. On the basis of visual acuity all the participants were divided into 04 categories of uncorrected visual acuity affected eye as well as normal one. All those patients who were having normal visual acuity were put in category 1st in which all those patients were enrolled who were having vision of in the range 6/6 to 6/9 and were considered normal regarding the size of pterygium.

In 1st there were 13 (31.7%) male patients and 09 (22.0%) female patients who were having above mention vision in right eyes, followed by the left eyes in which there were 17 (41.5%) males and 11 (26.8%) females and in both eyes 20 (48.8%) males and 12 (29.3%) females respectively were lying in this group. Similarly in category 2nd 09 (22.0%) male patients and 04 (9.8%) female patients were having vision in the range of 6/12-6/18 in their right eyes, followed by left eyes 06 (14.6%) males and 04 (9.8%) females respectively and there were 04 (9.8%) males and 04 (9.8%) females who were having same vision in both eyes as mentioned below in table 5.

Table 5: Uncorrected visual acuity in association with pterygium gender wise

Visual acuity	Uncorrected VA Male			Uncorrected VA female		
	OD	OS	OU	OD	OS	OU
6/6-6/9	13 (31.7)	17 (41.5)	20 (48.8)	09 (22.0)	11 (26.8)	12 (29.3)
6/12-6/18	09 (22.0)	06 (14.6)	04 (9.8)	04 (9.8)	04 (9.8)	04 (9.8)
6/24-6/36	01 (2.4)	00 (00)	00 (00)	02 (4.9)	00 (00)	01 (2.4)
>6/36	01 (2.4)	01 (2.4)	00 (00)	02 (4.9)	02 (4.9)	00 (00)

Association of Visual Acuity with Grades of Pterygium

The result shows a cross tab between visual acuity and grades of pterygium. Pterygium was divided into three grades on the basis of WHO gradings of pterygium and then these grades were then cross matched with the drop in visual acuity, however decrease in visual acuity in all cases were not purely because of pterygium in all cases in which table and figure 5.6 shows that in total of 41 participants 14 (34.1%) of the patients were having grade I pterygium in their right eyes were having a vision lying between 6/6-6/9, followed by grade II in which there were 08 (19.5%) participants were having same vision respectively. Similarly, there were 04 (9.8%) of the participants were having grade I pterygium in their right eyes with a vision of between 6/12-6/18, followed by grade II with 08 (19.5%) participants having vision in same group, while in grade 03 there was only one participant who was having vision in this line respectively. Similarly in grade II there were only 03 (7.3%) participants who were having vision of 6/24-6/36 and in there were 03 (7.3%) participants in grade III who were having vision dropped of greater than 6/36 respectively and so far for left eye and both eyes consequently.

Table 6: Association of Visual Acuity with Grades of Pterygium

		OD n (mm) (%)			OS n (mm) (%)			OU n (mm) (%)		
		Grade 1 0-2mm	Grade 2 >2-4mm	Grade 3 >4mm	Grade 1 0-2mm	Grade 2 >2-4mm	Grade 3 >4mm	Grade 1 0-2mm	Grade 2 >2-4mm	Grade 3 >4mm
Visual Acuity	6/6-6/9	14(34.1)	08 (19.5)	00 (0.0)	15(36.6)	11(26.8)	02(4.9)	17(41.5)	15(36.6)	00 (0.0)
	6/12-6/18	04 (9.8)	08 (19.5)	01 (2.4)	01 (2.4)	08(19.5)	01(2.4)	01(2.4)	04(9.8)	03(7.3)
	6/24-6/36	00 (0.0)	03 (7.3)	00 (0.0)	00(0.0)	00(0.0)	00(0.0)	00(0.0)	00(0.0)	00(0.0)
	>6/36	00 (0.0)	00 (0.0)	03 (7.3)	02 (4.9)	00 (0.0)	01(2.4)	00(0.0)	00 (0.0)	01(2.4)
Total		18(43.9)	19 (46.3)	04 (9.8)	18(43.9)	19(46.3)	04 (9.8)	18(43.9)	19(46.3)	04(9.8)

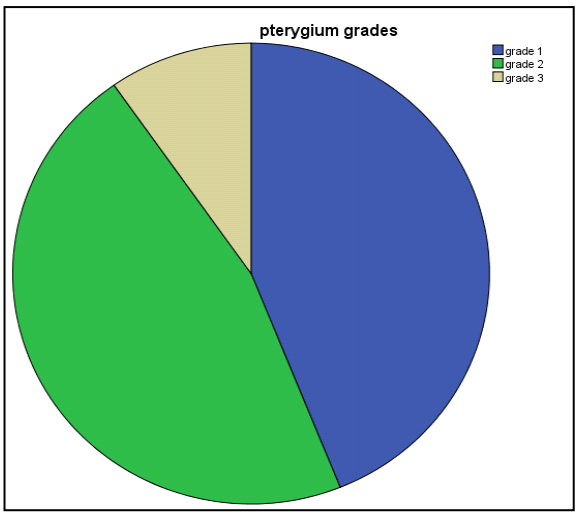

Figure 5: Pterygium grades

Cross Tab of Pterygium Grades with Types of Astigmatism

The result describes grades of pterygium associated with types of astigmatism is shown in table 7 that out of 41 participants 32 (78.0%) participants were having With the Rule (WTR) associated with the pterygium in which Grade I was having 15 (36.6%) of the participants, followed by grade II with total of 14 (34.1%) participants and grade III had 03 (7.3%) participants respectively. Next most common was Against the Rule (ATR) in which there were 07 (17.1%) participants, in which grade I was having 02 (4.9%), grade II was 04 (9.8%), and similarly grade III was having only 01 (2.4%) participants respectively. Participants with oblique astigmatism were only 02 (4.9%) in numbers the least common of three types in which there was 01 (2.4%) in grade I and 01 (2.4%) participant in grade II respectively.

Table 7: Cross tab of Pterygium grades with types of Astigmatism

		Types of astigmatism		
		WTRn (%)	**ATRn (%)**	**OAn (%)**
Pterygium Grades	Grade 1	15 (36.6)	02 (4.9)	01 (2.4)
	Grade 2	14 (34.1)	04 (9.8)	01 (2.4)
	Grade 3	03 (7.3)	01 (2.4)	00 (0.0)
Total		32 (78.0)	07 (17.1)	02 (4.9)

Cross Tab of Pterygium Grades and Degree of Astigmatism

The grades of pterygium associated with degree of astigmatism. Out of 41having mild degree of astigmatism associated with the pterygium in which Grade I was having 18 (43.9%) participants, followed by grade II with total of 07 (17.1%) participants and grade III had 00 (0.0%) participants respectively. Next most common was moderate degree of astigmatism in which there were total of 13 (31.7%) participants, in which grade I was having 00 (0.0%), grade II was 12 (29.3%), and similarly grade III was having only 01 (2.4%) participants respectively. Participants with severe degree of astigmatism were only 03 (7.3%) in numbers the least common of three types in which there were all 03 (7.3%) participants in grade III as described below in table 8.

Table 8: Cross Tab of Pterygium Grades and Degree of Astigmatism

		Degree of Astigmatism		
		Mild n (%)	Moderate n (%)	Severe (%)
Pterygium Grades	Grade 1	18 (43.9)	00 (0.0)	00 (0.0)
	Grade 2	07 (7.1)	12 (29.3)	00 (0.0)
	Grade 3	00 (0.0)	01 (2.4)	03 (7.3)
Total		25 (61.0)	13 (31.7)	03 (7.3)

Discussion

The purpose of this study was to find out pterygium induced corneal astigmatism and irregularities in patients attending eye opd, FIO hospital, Peshawar. Total of 41 participants were examined throughout the session, included both genders i.e. male and females, in which 24 (58.5%) were males and 17 (41.5%) were females irrespective of their ages.

Uncorrected visual acuity (UVA) of both eyes (OU) was observed first and then Right eye (OD), and Left eye (OS) respectively. In the right eye, most of the participants 22 (53.6%) were having VA in the range of 6/6-6/9 and 13 (31.7%) were in the range of 6/12-6/18 and 03 (7.3%) were in the range of having visual acuity worse than 6/24-6/36 and 03 (7.3%) was having visual acuity of worse than 6/36 in their right eye respectively. In the left eye, most of the participants 28 (68.2%) were having VA in the range of 6/6-6/9,

while 10 (24.3%) were having VA in the range of 6/12 to 6/24 and 03 (7.3%) were in the range of having visual acuity worse than 6/36 respectively. Binocularly UCVA of the participants 32 (78%) were having VA of 6/9 or better than 6/9, while 08 (19.5%) participants were having VA of 6/12 to 6/24 and 01 (2.4%) participants were in the range of visual acuity of 6/24-6/36 and 00 (0.0%) were in the range of visual acuity worse than 6/36 respectively. In other words out of 41 participants, 22 (53.6%) were having no or mild refractive errors, while other 19 (46.3%) had refractive errors either associated with pterygium or with some other causes.

In this study it can be seen that higher the grade of pterygium greater is the value of astigmatism and worse is the vision output which is comparable with the studies take in Turkey, Thailand, Japan, and Pakistan (Kampitak, et al., 2016, B, Sohail, et al., 2021, Gumus K, et al., 2011, Ono T, et al., 2020).

In this study the prevalence of the most prevailing astigmatism type associated with pterygium in the affected eye was found to be WTR 32 (78.0%), followed by ATR 07 (17.1%), and Oblique astigmatism 02 (4.9%) respectively which is comparable with studies taken in Turkey where WTR astigmatism was found to be 24 (60%), followed by ATR 03 (7.5%), and OA 05 (12.5%) respectively, similarly in South Korea in which the prevalence of WTR astigmatism was found to be 42 (71.1%), followed by oblique astigmatism 13 (22.0%), and ATR astigmatism 04 (6.7%) respectively, in Malaysia With-the-rule was the main type of pterygium-induced astigmatism with the prevalence of (49.4%), followed by against-the-rule (36.4%) and oblique astigmatism (14.3%) respectively and in Pakistan (Lahore) 21(42.0%) patients were having grade 1 pterygium and 21(42.0%) patients were grade 02 and 08(16.0%) patents have grade 3 pterygium respectively, in Iran the prevalence of WTR astigmatism was found to be the most which was 83 (63.8%), followed by oblique astigmatism 34 (26.2%), and similarly ATR astigmatism 13 (10.0%) respectively (B, Sohail, et al., 2021, Gumus K, et al., 2011,15 Mohammad Salih and Sharif, 2008, Yoon CH, et al., 2023, Aidenloo NS, et al., 2013).

In our study most the participants were having grade II pterygium 19 (43.6%) which in millimeters were found to be greater than 2mm to 4mm, followed by grade I pterygium 18 (43.9%) which was 0-2mm in size and grade III pterygium was found to be 04 (9.7%) and was severe which was >4mm in size respectively which is comparable with the studies taken in Lahore (Pakistan) where the prevalence of grade II pterygium was 21 (42.0%), followed by grade I pterygium 21 (42.0%), and similarly grade III pterygium 08 (16.0%) respectively, Rawalpindi (Pakistan) where the prevalence of grade pterygium was having a prevalence of 37 (61.6%), followed by grade II pterygium 20 (32.7%), and similarly grade III pterygium 03 (5.0%) respectively, in Ethiopia the prevalence of grade I pterygium was found to be 97 (64.2), grade II pterygium was 52 (34.4%), and similarly grade III pterygium was having a prevalence of 09 (5.9%) respectively (B, Sohail, et al., 2021).

Recommendations

There may be community-based awareness campaigns and other training sessions to help people learn more about the risk factors and protective measures associated with pterygium. Implementing a routine community screening program is crucial.

Reference

Aidenloo, N. S., Mikaili, P., & Farajpour, S. (2013). Studying the type of astigmatism in patients with corneal pterygium referring to ophthalmology clinics of northwestern Iran. *Life Sciences Journal*, 10(1), 782-784.

Sohail, B., A., Faridi, T. A., Jan, U., Zahid, F., & Parveen, I. (2021). Relation between different grades of pterygium and amount of induced corneal astigmatism: Different grades of pterygium. Pakistan *BioMedical Journal*, 14(2), 59-63.

Garg, S., Dubey, S., & Priyanka. (2022). Study of corneal curvature with pterygium morphology in tertiary care center in central India. *Journal of Ophthalmology Research Reviews & Reports*, SRC/JORRR-152, 141, 2-5.

Govindasamy, S., & Chandrasekhar, S. C. (2022). Outcome of excision of primary pterygium with bare sclera technique: A study of 80 eyes in Malaysia. *European Journal of Medical and Health Sciences*, 25(4), 17-20.

Gumus, K., Erkilic, K., Topaktas, D., & Colin, J. (2011). Effect of pterygia on refractive indices, corneal topography, and ocular aberrations. *Cornea*, 30(1), 24-29.

Jaffar, S., Dukht, U., & Rizvi, F. (2009). Impact of pterygium size on corneal topography. *Rawal Medical Journal*, 34(2), 145-147.

Kampitak, K., Leelawongtawun, W., Leeamornsiri, S., Suphachearaphan, W., & Thitiwichienlert, S. (2016). A comparative study of higher-order aberrations between pterygium and non-pterygium eyes. *Journal of Medical Association of Thailand*, 99(Suppl 4), S178-S181.

Mohammad-Salih, P. A., & Sharif, A. F. (2008). Analysis of pterygium size and induced corneal astigmatism. *Cornea*, 27(4), 434-438.

Ono, T., Mori, Y., Nejima, R., Lee, J., Abe, K., Nagata, Y., Iwasaki, T., Aihara, M., & Miyata, K. (2020). Long-term changes and effect of pterygium size on corneal topographic irregularity after recurrent pterygium surgery. *Scientific Reports*, 10(1), 8398.

Parveen, S. (2016). Effect of axis orientation and amount of astigmatism on visual acuity. *Ophthalmology Pakistan*, 6(04), 23-26.

Tandon R, Vashist P, Gupta N, Gupta V, Yadav S, Deka D, et al. (2022) The association of sun exposure, ultraviolet radiation effects and other risk factors for pterygium (the SURE RISK for pterygium study) in geographically diverse adult (≥40 years) rural populations of India -3rd report of the ICMR-EYE SEE study group. PLoS ONE 17(7): e0270065

Yoon, C. H., Seol, B. R., & Choi, H. J. (2023). Effect of pterygium on corneal astigmatism, irregularity and higher-order aberrations: A comparative study with normal fellow eyes. *Scientific Reports*, 13(1), 7328.