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ANALYSIS OF CORNEAL ASTIGMATISM IN PATIENTS WITH PTERYG

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ABSTRACT

Pterygium is a fairly common ocular condition which can have a significant effect on visual acuity and quality of vision due toits warping effect on corneal topography andas a consequence on the induced astigmatism. Our study demonstrated that the length of thepterygiumcorrelates with the amount ofhours spent insunlight. UV exposure causes the alteration of limbal stem cellsandfibroblaststhat contribute to the initiation of pterygia and the induction of various pro-inflammatory cytokines, growth factors and matrix metalloproteinases that promote the progression of pterygia. Most of our patients did not use sun protection of any kind and as a result had more UV exposure

Keywords
Pterygium, Pentacam, Pachymetry map, atigmatism

INTRODUCTION

The word “pterygium “is a derivative of *pteryx,* whichin Greek means wing. It has been recognized since ancient times and described by the world’s first known ophthalmologist Susruta, as early as1000BC.Pterygium is a superficial, elevated, external ocular wedge shaped dysplastic growth of bulbarconjunctivathatencroaches onto the cornea[1,2]. A pterygium that isrestricted to 1 to 2 mm of the peripheral cornea has negligible effect on visual acuity and usually is only ofcosmeticconcern.However, the growth of pterygium is associated with astigmatismon the corneal plane[3] and could lead to visual loss in advanced stages owing to obscuration of thevisualaxisofthe cornea[4]. Pterygium is associated with a wide spectrum of issues like sunlight and UV exposure [5], which is the reason why pterygium is morecommonly seenintropical climates[6]. Moreover, pterygium is associated with factors like age, ethnicity, sex [7], and environmental conditions like outdoor occupations[8] due to exposure to sunlight. The prevalenceratesofpterygiumobtainedforanumberofpopulationsvarywidely, [9,10,11,12] from1.2%inurban, whitepeople[13] in temperate climes to 23.4% intheblack population of tropical Barbados [6].

Determination of pterygium-induced astigmatism by evaluating factors influencing corneal astigmatism is important for prediction of the degree of change in corneal astigmatism and visual prognosis. It is also important for making decisions regarding pterygium surgery and patient selection, as this is often difficult because of recurrenceafter pterygium surgery[14,15]

Correlation has been found to be significant between the encroachment of the pterygium onto the corneal surface and the quantum of astigmatism error induced. Anpterygium advancing on to the cornea can produce discernable changes in refractive state and curvature before growing into the optical zone, which can cause impairment of vision. [16] The change is usually categorised as with-the-rule astigmatism resulting from localized corneal flattening from the central zone to the leading apex. However there is weak correlation betweencornealastigmatisminducedbythe pterygiummeasuredbytopographyandthatgaugedbymanifestrefraction. Pentacam (Oculus GmbH, Wetzlar, Germany) quantifies anterior and posterior corneal astigmatism, elevation, and wave front aberrations which are altered by pterygia. The Oculus Pentacam employs Scheimpflug technology to generate topographic reports. Pentacam maintains the central position in each

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meridian when it captures image slices of the cornea, hence eliminating inaccuracies due to eye movement. The technology is superior to previous topography systems andwethushope it will provide a better comprehension of induced astigmatism due to pterygia.

In this study we aim to study the corneal involvementby pterygia using Pentacam (Scheimpflug imaging), and examine its associations withvisualacuity,astigmatism, and topography.[17]

For thousands of years, physicians across theworld have dealt with anunsightly elevated corneal lesion knownas pterygium. A pterygium is a horizontally oriented triangular shaped growth of abnormal tissue that extends on to the cornea from the bulbar conjunctiva near the canthus. Its development is not related to previous inflammation or trauma.Apterygium can be divided into threeidentifiable parts: body, apex (head), and cap. The raised portion of the pterygium which is triangular in shape with its base facing the canthus is the body, while the apex of the triangle forms the pterygium head, just posterior to the cap. Asub- epithelial "halo" or cap may be present just adjacent to theapex and forms its leading edge.

Parts of a pterygium

1. The head ofthe pterygium isavascular and resemblesa white thick scar.
2. A Stocker line is due to deposition of iron within the epithelium which occurs due to an uneven tear distribution adjacent to the elevated edge of the pterygium.

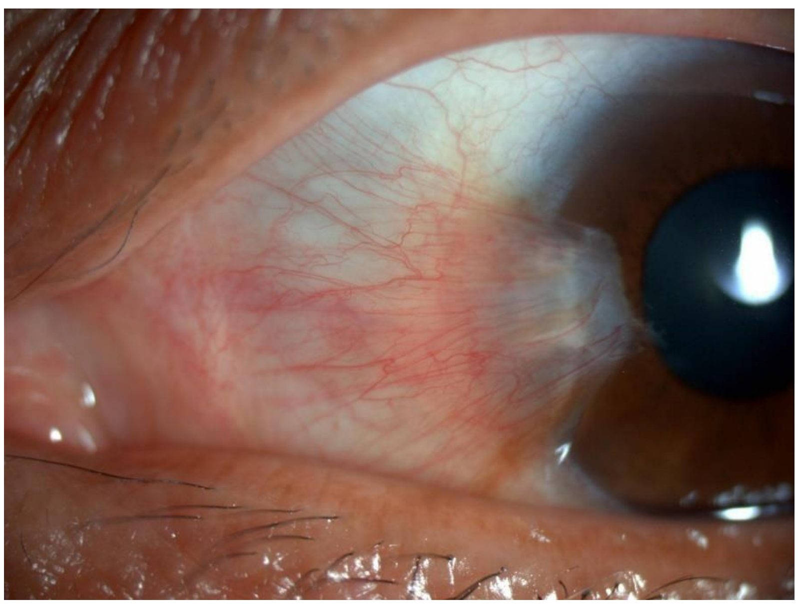

Figure 1:Primary Pterygium

Aetiology and Epidemiology

Pterygium prevalence is of worldwide distribution, but it is more commonly seen in warm and dry climates. In the northern temperate climates, pterygium is almost exclusively restricted to fishermen and rural workers who spend lot of time outdoors. Taylor et al found a statistically significant link between ultraviolet light exposure (both UV-A and UV-B) and the development of pterygium in fishermen in Chesapeake bay[23]. Fromtheseresearch articles, the relationship between ultraviolet exposureand the formation of pterygium is quite strong. However, ultraviolet light exposure may not be the only factor linked withpterygiumdevelopment.Amongstworkersinthe

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IndianstateofPunjab,thoseexposedtoadusty,indoor environment had a higher incidence of pterygia than workers who experienced higher levels of outdoor ultraviolet radiation[24]. Local drying of the cornea and conjunctiva in the inter-palpebralfissure from abnormalities in the tear film meniscus may lead to new fibroblastic growth according to one postulation. The increased prevalence of pterygium in dry, windy climates is consistent with this proposition. Children younger than the age of 15 rarely develop a pterygium.

Histopathology

The histopathologicdecription of pterygia were painstakingly outlined by Fuchs in the 1890s. These include an augmented number ofthickenedelasticfibers, conjunctival tissue undergoing hyaline degeneration, concretions, and changes in the epithelium.

Austinetal[25]havebrieflyencapsulatedthe histopathologic findingsas follows:

1. Hyalinization of thesub-epithelialconnectivetissue in the substantiapropria.
2. Lobular or diffuse collections of granular eosinophilicmaterial with an concomitantincreaseintheamount of fibroblasts and other cells.
3. A greater number oftortuousandthickenedfibers that stain intensely with elastic stains (elastotic material)
4. Concretions inside the granular and hyalinised areas that demonstrate either eosinophilia or basophilia.A secondary or recurrent pterygium is defined as a pterygium recurrence after primary surgical removal.

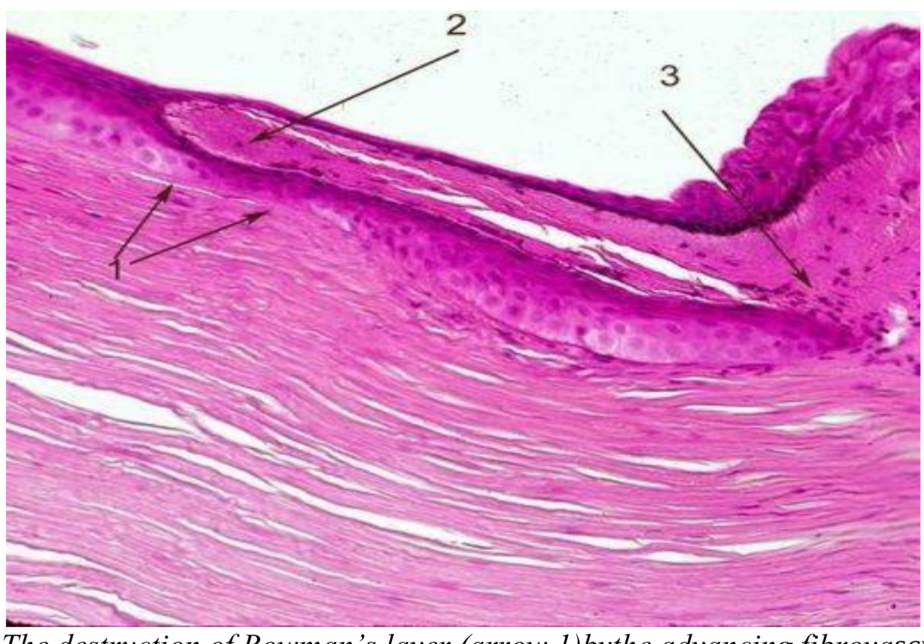

Figure 2: The destruction of Bowman's layer (arrow 1)bythe advancing fibrovascular tissue resultsina corneal scar. There is accompanying pannus formation(arrow2) and chronic inflammation (arrow 3)

Secondary pterygia differ from primary pterygia histologically in that the usual degenerative connectivetissue changes are absent. Cameron [27] suggested that the surgical trauma after primary excision leads to an accelerated fibro-vascular proliferative response.

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Pathogenesis

Initial research by Cameron [29] showed that pterygia occur more frequently where ultraviolet light intensity is highest. In particular, an increased incidence of pterygia occurs in an equatorial between latitudes 37°north and 37° south. Confirming Cameron's observations, Mackenzieetal[30] found that those who live at latitudes lessthan30° during the initial 5 years of life have a40 - foldincreasedrisk of pterygium formation. On the whole, it is generally believed that ultraviolet light exposureisassociatedwith the formation of pterygia. Additional support for this postulation is the observation that pterygia aremore frequent in those who working the open, specifically if the working environment is on or near a highlyreflectivesurface.

Pterygium is strongly related to ocularsunexposure. It does not seem to matter that exposureduringany particular period of life is more important than in other periods. Interestingly, neither ultraviolet light exposure nor exposure to dust and smoke completely explains the observation that pterygia are more frequently found on the nasal bulbar conjunctiva. Several theories have been putforth to explain this finding:

1. The temporal surface of the eye is usually protected from light by the longereyelashesandcurvatureof the temporal upper eyelid,
2. The normal orbicularis contraction in bright light provides greater relative coverage of the temporal bulbar conjunctiva, and
3. Light rays incident from a postero-lateral aspect to the eye is focused by thetemporalcornealperipheryto the region of the nasal limbus,causingfocallimbal stem cell dysfunction.

Regarding the last theory, it is assumedthatthenormal anatomic positions of the noseandtheeyelids would offer relative ocular shielding of incident light from the superior, inferior, and nasal directions.

The use of Scheimpflug principle has helped in providing sharp and crisp images that include information from the anterior corneal surface to the posterior crystalline lens capsule. The major advantages of the rotating imaging process are the accurate measurement of the central cornea, the compensation of eye movements, the easy fixationforthe patients and the extremely short examination time.

INTERPRETING PENTACAM

The four most important tomographic maps in the Pentacam are the anterior curvature sagittal map, the anterior and posterior elevation maps, and the pachymetry map .In each map, both shape parameters should be studied. It is necessary sometimes to study the anterior curvature tangential map

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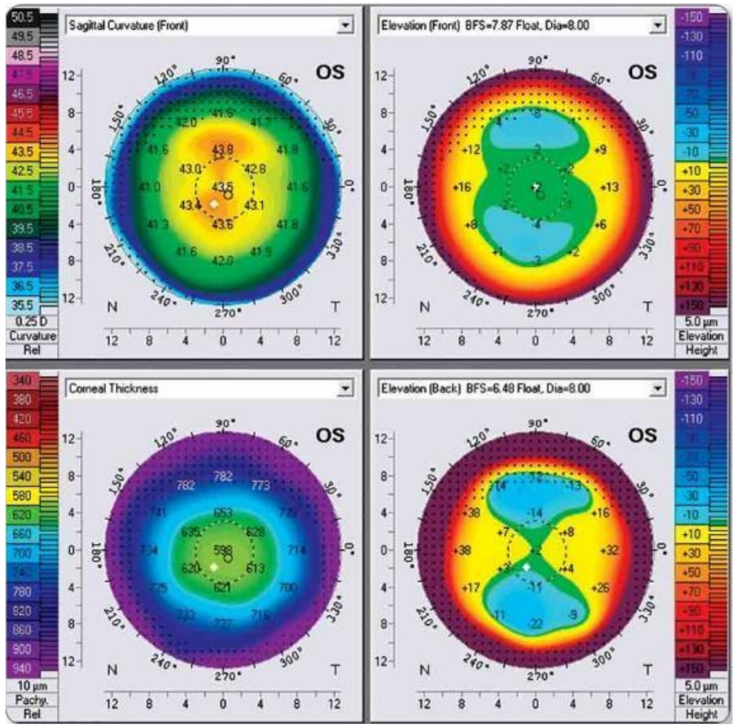

Figure 4 The 4-view refractive compositemapcontaining the four main maps anterior sagittal, anterior and posterior elevation, and the pachymetry maps:

The Anterior Sagittal Map

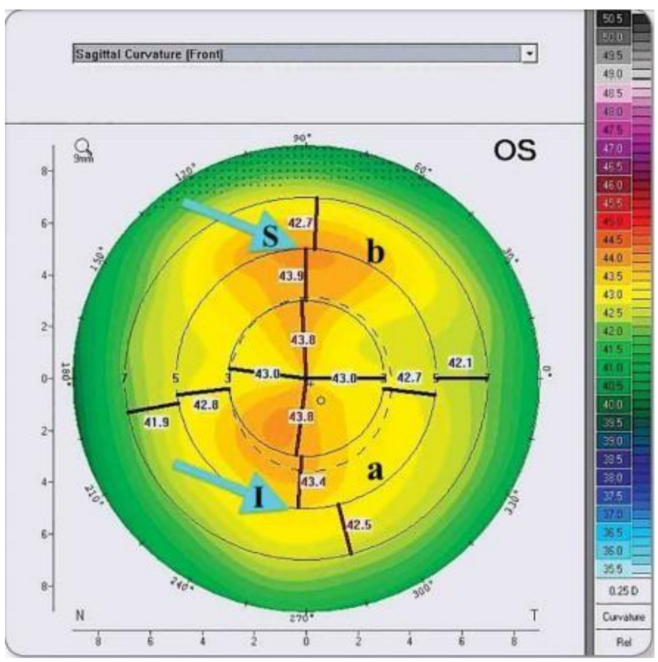

Figure 5 Theanterior sagittal map. Thenormal pattern isthe symmetric bowtie consisting of twosegments(a)and (b). The cyan arrows point at the two opposing inferior (I)and superior (S) points on the steep axis onthe central 5 -mm circle. The vertical SB indicates with-the-rule astigmatism

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Figure 5 characterises anterior surface dioptric power measured by the sagittal method. Steep areas are shown ashot colours (red andorange), while flat areas arepresented in cold colours (green and blue). On the other hand, redsegments are displayed on steep areas, while blue segments are displayed on flat areas. The cross point of this segmentation denotes apex (anatomical center) of the cornea. Beside the shape of the map, parameters should be studied particularly on the steep axis at the 5 -mm central circle. The normal pattern is the symmetric bowtie (SB) (Figure 5). In this figure, the two segments (a) and (b) ar e equal in size, and their axes are aligned. The two opposing points (S and I) on the 5 -mm central circleonthesteep axis. Usually, the inferior (I) point has ahigher value thanthe superior (S) one, and the I-S difference should be <1.5D. The superior point may rarely havea higher value than the inferior one; in this case, the S-I difference should be < 2.5 D. The SB patternrepresentsregularastigmatism,which can bewith-the-rule (WTR),against-the-rule (ATR) or oblique according to the orientation of the symmetrical bowtie.

a. In WTR astigmatism, the SB is onorwithin±15° of the vertical meridian of the cornea
b. In ATR astigmatism, the SB ison orwithin ±15° ofthe Horizontal meridian of the cornea, as shown inFigure 6
c. In oblique astigmatism, the SB is neither vertical nor horizontal, as shown in Figure 7.

The SB pattern can be encountered in KC when K readings are abnormally high as show in Figure 8.

Abnormal patterns are illustrated in Figure 9.These patterns are better seen on the tangential map. They include the following:

1. Round
2. Oval
3. Superior Steep (SS)
4. Inferior Steep (IS)
5. Irregular (Irr)
6. Abnormal Symmetric Bowtie (SB
7. Symmetric Bowtie with Skewed Radial Axis (SB/SRAX). The angle between the axes of the two lobes is >22
8. Asymmetric Bowtie/Inferior Steep (AB/IS); the I -S difference is >1.5 D
9. Asymmetric Bowtie/Superior Steep (AB/SS); the S-I difference is >2.5 D
10. Asymmetric Bowtie with Skewed Radial Axis (AB/SRAX). The angle between the axes of the two lobes is >22°

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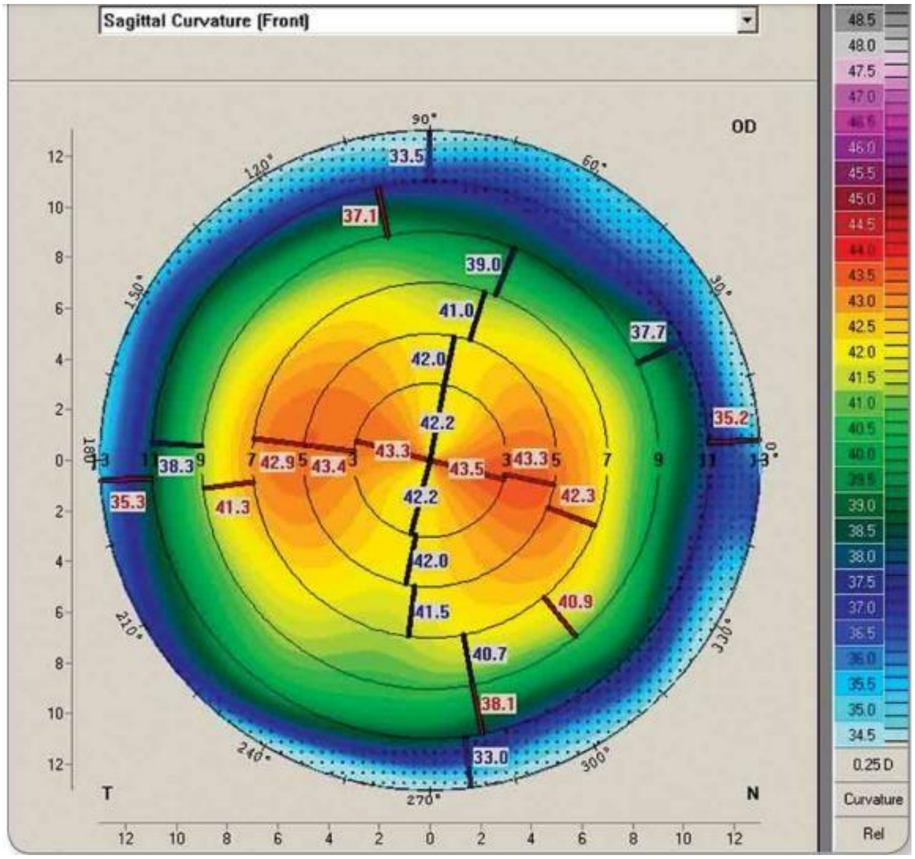

Figure 6 Horizontal symmetric bowtie indicating against- the-rule astigmatism

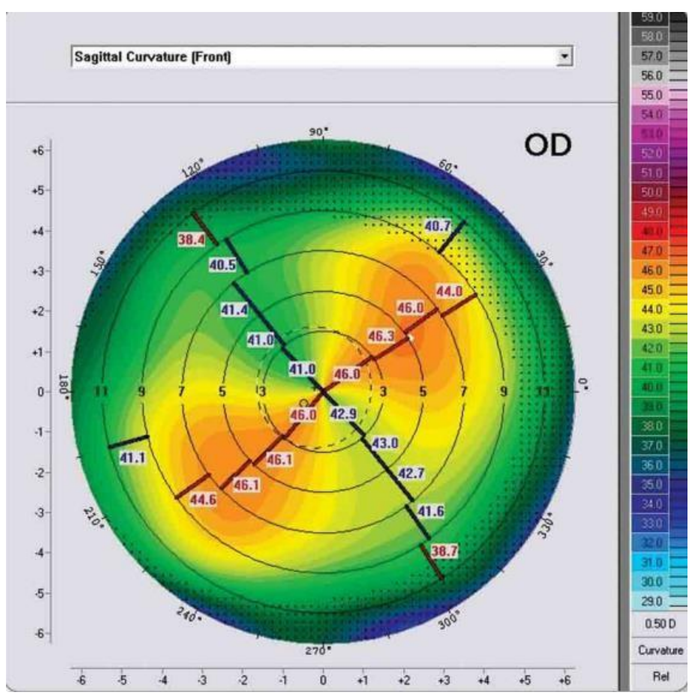

Figure7Obliquesymmetricbowtieindicatingoblique astigmatism

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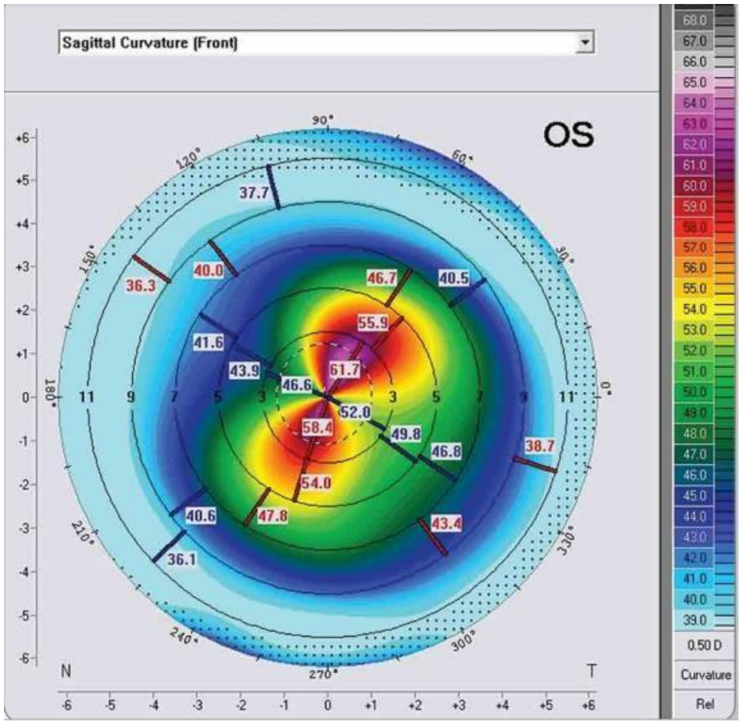

Figure8Abnormalsymmetricbowtie.Kreadingsare abnormal

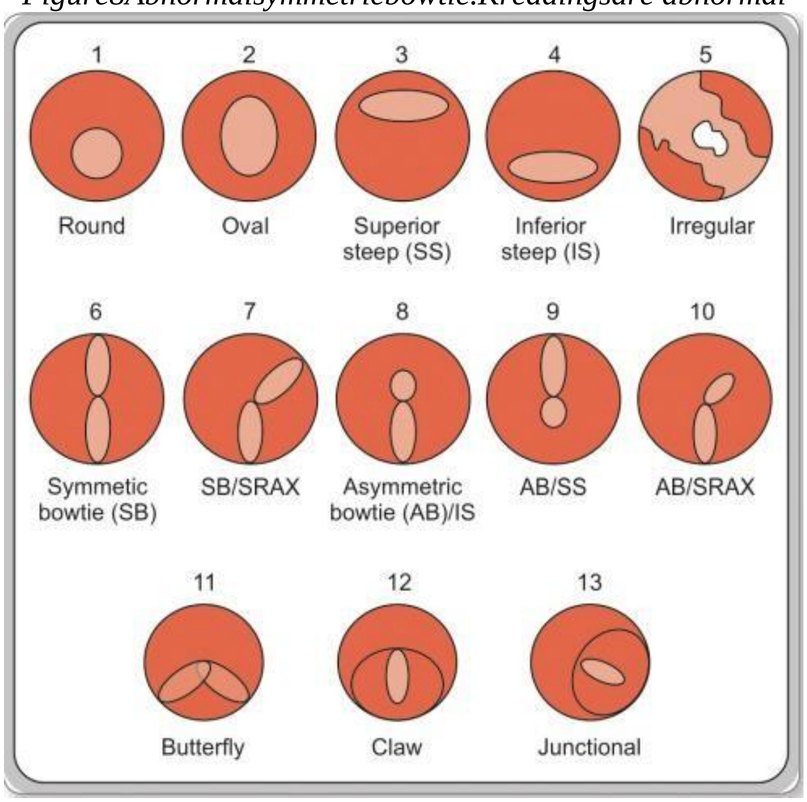

Figure 9 Abnormal patterns of the anterior sagittal map

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The Elevation Maps

An elevation map describes the height details of the measured corneal surface by matching it with a reference surface (RS). Points above the RS are considered elevations and expressed in plus values, and those below the RS are considered depressions and expressed in minus values, as shown in Figure 10.In corneal astigmatism, one meridian is steeper than the other and is located under the RS taking minus values, contrary to the flatter meridian which takes plus values . There are several shapes of the RS, the most important are best fit sphere (BFS) which describes (qualifies) the shape of the measured surface, and best fittoric ellipsoid (BFTE) which estimates (quantifies) the parameters of that surface.
Shape (BFS float mode): The normal shape of a cornea with regular astigmatism is the symmetric hourglass asshown in Figure 12.
The Pachymetry Maps

The pachymetry map has three main landmarks as shown in Figure 13: cornea apex (orange arrow), Thinnest location (TL) (red arrow), and the twoopposing points onthe vertical meridian at the central 5 -mm circle(white dotted arrows). The normal difference between the superior(S) and inferior (I) points is ≤ 30 μm.

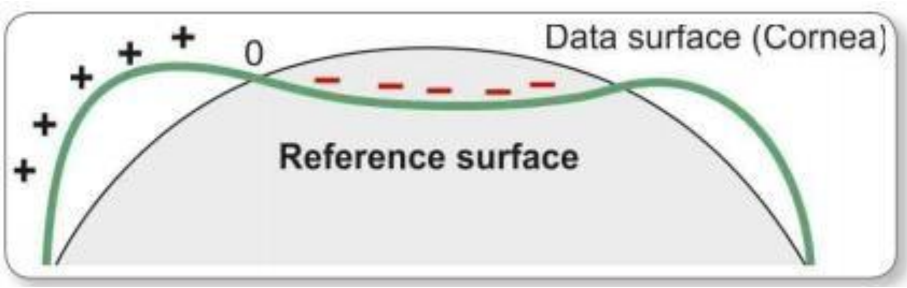

Figure 10 General principle of the elevation map

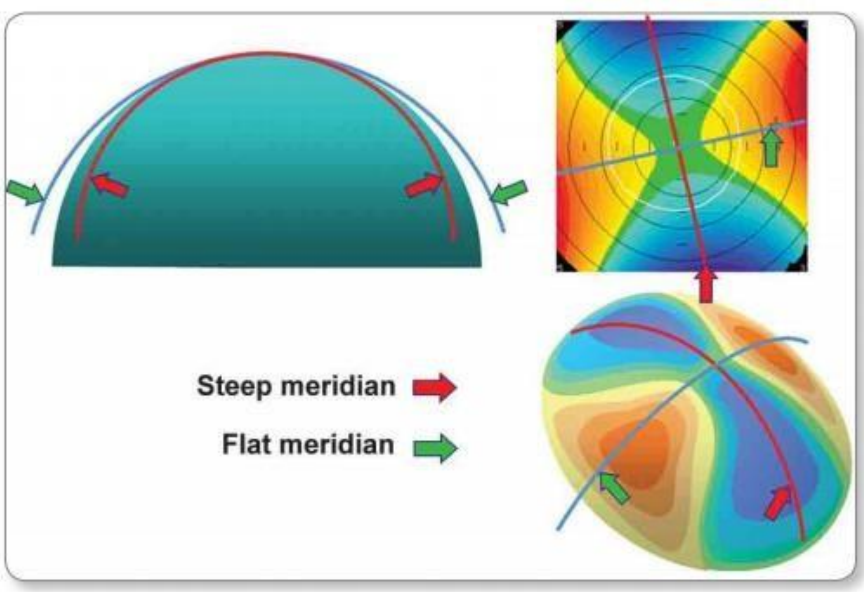

Figure 11 Shape of elevation map in corneal astigmatism using the best-fit sphere reference surface

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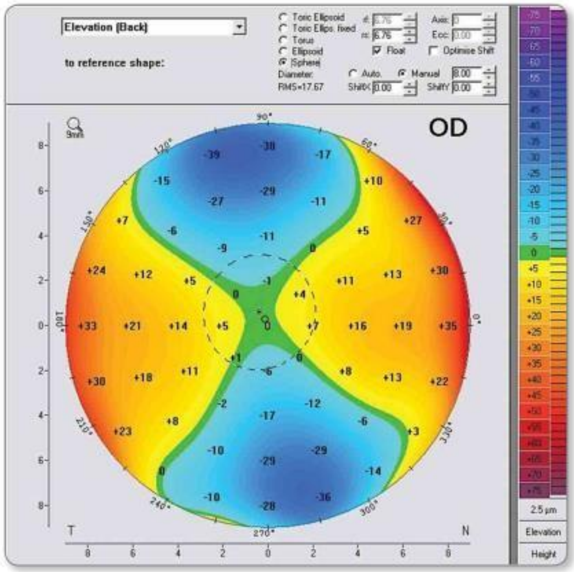

Figure 12 The normal "symmetric hourglass pattern". In with-the-rule astigmatism, the hourglass is vertically oriented because the vertical meridian is steeper than the horizontal one.
Shape:

The normal pachymetry map has a concentric shape shown in Figure 13 .
Abnormal shapes include:

a. Horizontal displacement of the TL.

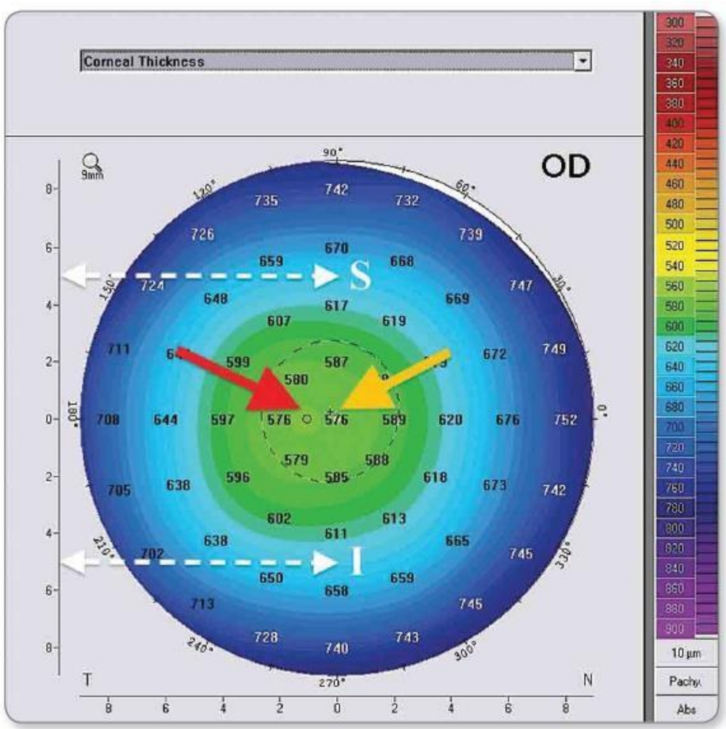

Figure 13 : The normal concentric shape of the pachymetry map: apex (orange arrow); thinnest location (redarrow); the two opposing superior (S) and inferior(I) points at the central 5-mm circle (dotted arrows)

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b. Bell shape. There is a thin band in the inferior part ofthe cornea. It is a hallmark for Pellucid Marginal Degeneration (PMD).
c. Keratoglobus. A generalized thinning reaching the limbus.

Thickness Profiles
These profiles are only displayed in the Pentacam. Figure 14 shows the two pachymetry profiles: corneal thickness spatial profile (CTSP) and percentage thickness increase (PTI). The former describes the average progression of thickness starting from the TL to corneal periphery in relation to zones concentric with the TL. The latter describes the percentage of progression of the same.
The normal profile is a curved line plotted in red, following (but not necessarily within) the course of the normative black dotted curves, with an average of 0.8 –1.1 (red ellipse in Figure 14). When there is a fast transitionofthicknessbetween the TL and corneal periphery, the average will be high, and vice versa; e.g. inan oedematous cornea, the average will be low and the curve will be flat.

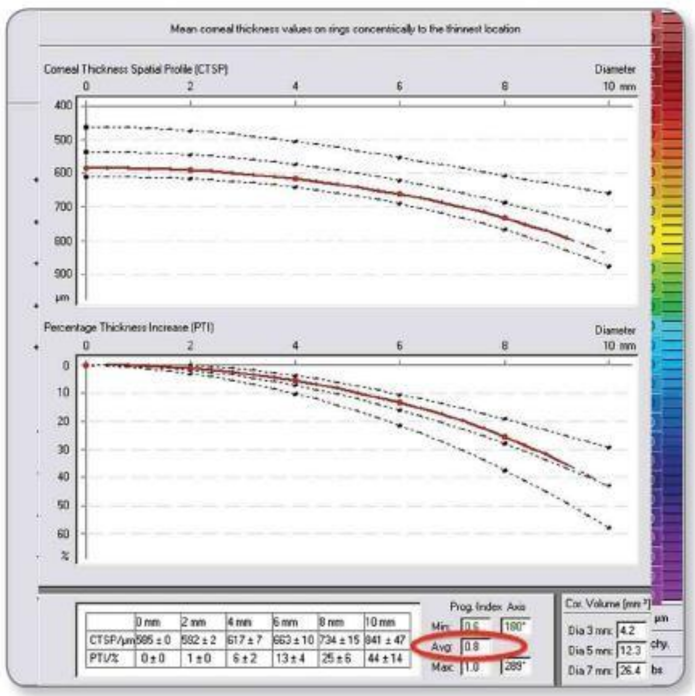

Figure 14: *Thickness profiles. A normal profile follows the normativecurves with an average < 1.2 (red ellipse)*

PROBLEMS FACED WHICH WERE OVERCOME BY THE PENTACAM

The problem with using standard keratometers is that they are completely blind to the central cornea, measuring instead an intermediate zone and extrapolating a central value. A placido based topographer, also has a blind spot in the center. In the case of patients who have undergone prior myopic refractive procedures, this issue may lead to a significant overestimation of the central corneal power.[50]

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The Pentacam, on the other hand measures the central cornea and the anterior and posterior corneal surface very precisely. Thus it can precisely predictapatient's net corneal power which can help to predict an implant's power. The standard keratometers were found to be unreliable to calculate the proper IOL power in such patients as they calculated the refractive power using an approximate ratio between back/front corneal radii (approximately 82.5%), which leads to an overall corneal refractive index of 1.33. Because refractive surgery alters this relationship, these keratometricmeasurementscannotbeacceptabletobepluggedintostandardIOLformulaswithoutperfo rmingadditional recalculations. However, in the"Holladay Report" incorporated in the Pentacam software the ratio between back and front power ofthecornea iscalculatedfor the current examination as well as the "Equivalent K - Readings" of the cornea. These"EquivalentK-Readings" can be implanted into the IOL calculation formulas to get a more precise IOL power calculated for all patients, including those with abnormal corneas.

ADVANTAGES OF THE PENTACAM

Imaging methodology: The Pentacam is the only Scheimpflug device that rotates around a common axis and allows the user to toggle down througheachindividual image and to see if there is a blinking eyelidoreye movement that degrades the image's quality for that meridian.

Newer Software

- The New Holladay Software facilitates for an improved and less tedious IOL power calculationin postrefractive patients.
- The Phakic IOL simulation software is extremely useful to plan phakic IOL implantations by imaging and calculating the dimensions of the anterior chamber for adequate space
- The Pentacam's densitometry software simplifies

cataract grading into a single, test that provides areliable, reproducible way of sampling the volume and density of the nuclear cataract and objectively classifying it into different grades. Having this pre - operative knowledge, allows surgeons to pre-program their phaco-emulsification systems tohandlethe specific density of cataract efficiently.

- With the option of new Contact Lensfitting software,the Pentacam HR has become, the most versatile instrument for the advanced optician/optometrist
- The learning curve is also very short and the machine is friendly for both the patient and the operator.
- The inter-operator reliability is higher using the automatic release mode.

AIM AND OBJECTIVE

AIM:

To analyse the effect of pterygium on Corneal Astigmatism with the help of rotating Scheimplflug imaging (Pentacam)

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OBJECTIVES:

1. To assess the effect of pterygium on Corneal Astigmatism using Scheimpflug imaging
2. To study the various clinical presentations of Pterygium
3. To investigate possible relationships between thesize of the pterygium and patient age, sex, sunlight exposure and amount of astigmatism.

MATERIALS AND METHODS

STUDY DESIGN

A prospective study of sample size 50 patients with pterygium attending the ophthalmology out-patient departments during December 2017 – January 2019 at SreeBalaji Medical College.

SELECTION CRITERIA

Inclusion criteria:

- Patientsaged18 years or older with diagnosis of pterygium more than 1mm
- Patients with primary or atrophic pterygium

Exclusion Criteria:

- Patients with recurrent pterygium
- Patients with double headed pterygium
- Patients with visual acuity < 6/18
- Patients with other corneal pathology

This study included a series of 50 patients selected within the constraints oftheinclusion criteria. The patients' history of presenting illness is noted and history of hours spent outdoors and history of the use of sun protection were enquired. Then the patient was examined under diffuse illumination and by using the slit lamp. Thesize of the pterygium its extent were notedandthe pterygium was graded accordingly by using the horizontal beam of the slit lamp. The orbital anatomy wasnoted andalso the normalcy of the lid closure was noted. After this is done the patient then underwent refractionbya refractionist, manual keratometry readings were obtained. Then the patient was screened using a Pentacam HR Scheimpflug machine. Results were depicted as scatter plots and bar graphs and analysed by linear regression to determine the relationship between diopters of induced astigmatism and the size of extension of the pterygium. All data was entered in the master chart and statistical methods were performed with SPSS for Windows, version 11.0.1 and Microsoft Excel 2013 .

OBSERVATIONS

SEX

Gender	N (%)
Male	27 (54.0)
Female	23 (46.0)
Total	50 (100.0)

AGE DISTRIBUTION

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Age (in yrs)	
Number of patient’s	50
Mean ± SD	57.3 ± 11.1
Minimum, Maximum	28, 77

DURATION OF HOURS SPENT IN SUNLIGHT

Time spent in sunlight(in hours)	
No of observations	50
Mean ± SD	3.6 ± 2.8
Minimum, Maximum	0, 12

DURATION OF PTERYGIUM

Duration of pterygium (in months)	
No of observations	50
Mean ± SD	96.6 ± 79.9
Minimum, Maximum	3, 360

SUN PROTECTION

Person using sun protection	**N (%)**
Yes	5 (10.0)
No	45 (90.0)
Total	50 (100.0)

LATERALITY

Eye involved	**N (%)**
Right	12 (24.0)
Left	18 (36.0)
Both	20 (40.0)
Total	50 (100.0)

LOCATION

Location of pterygium	**N (%)**
Nasal	65 (92.9)
Temporal	5 (7.1)
Total	70 (100.0)

TYPE OF PTERYGIUM

Type of pterygium	**N (%)**
Primary	60 (85.7)
Atrophic	8 (11.4)
Recurrent	2 (2.9)
Total	70 (100.0)

LENGTH OF PTERYGIUM

Length of pterygium (in mm)

No of observations	70
Mean ± SD	3.5 ± 1.5
Minimum, Maximum	0.5, 8.0

DISCUSSION

Pterygium induced astigmatism can be substantial and cause subjective visual disturbance. Previous studies have shown increased with-the-rule astigmatism in patients with pterygia measured by either refraction orkeratometry.In this study this correlation was quantified by using the Pentacam machine producing color-coded dioptric maps of the corneal surface. We also calculated the SIM K (simulated keratometry) value, providing the power and location of the steepest and flattest meridians for the 3 mm opticalzone. The manual keratometry is limited in that it
only measures the central cornea and the optical zone it measures is dependent on the steepness of the cornea.

The amount of astigmatism measured in our patients represents the naturally occurring atigmatism plus the induced effect of the pterygium. The induced astigmatism is always with the rule whereasnaturallyoccurring astigmatism can occur in any axis.In our study, the age of the50 patients surveyed varied from 28 to 77 years of age with a mean age of 57.3 years. Patients were almost equally split by gender, with 27 males and 23 female patients

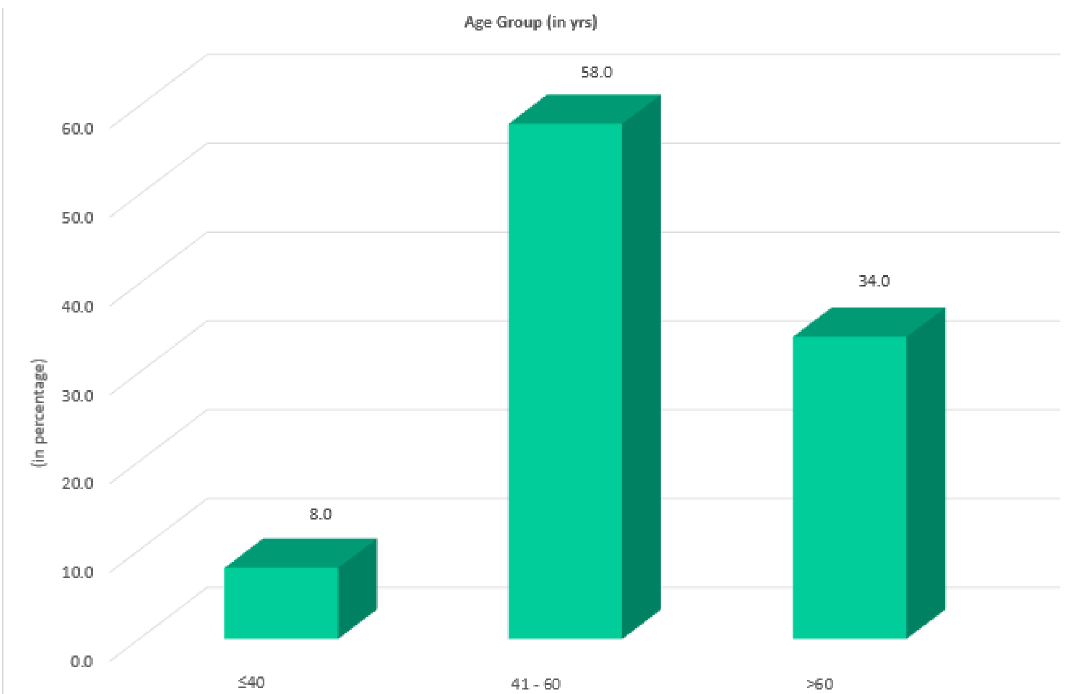

Figure 15: Age Distribution

On average most of ourpatients spent between 3 -4 hours in sunlight everyday. Majority of patients in our study didnotuseany sort of sun protection with only 10% of patients surveyed using sunglasses or hats/caps during the time spentinsunlight. The average duration that the patients had the pterygium at presentation was between 5 to 10 years with a mean of 96 months.Out of the 50 patients in the study, 30 patients had a pterygium in only one eye,whereas

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20 patients had bilateralpterygium. Hence our observations with regards to astigmatism and size were of 70 pterygia.

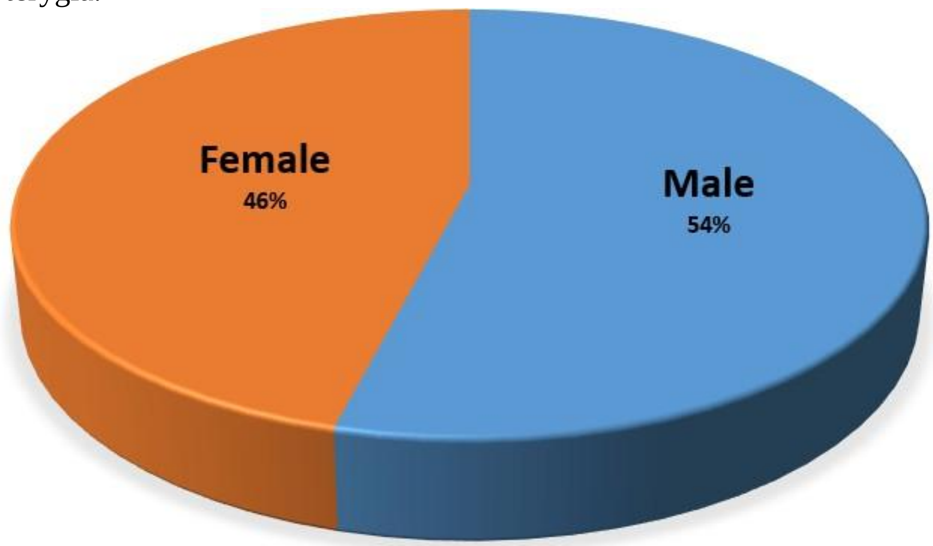

Figure 16 : Gender Distribution

92.9 % of the observed pterygia werenasalin location with only 5 pterygia having a temporal location.85.7% of the pterygia were classified as primary pterygium with 11.4 % being atrophic in nature and only 2 patients having a recurrent pterygium.

The mean length of the pterygia examined was 3.5 mm with a standard deviation of 1.5mm. The astigmatism measured using SIM-K values of thepentacaminthecentral 3mm zone was 2.5D with a standard deviation of 3.2D.Astigmatism was also measured using manual keratometer. In 10 patients, manualkeratometerwasnot able to quantify the K values due to severe distortionof mires.

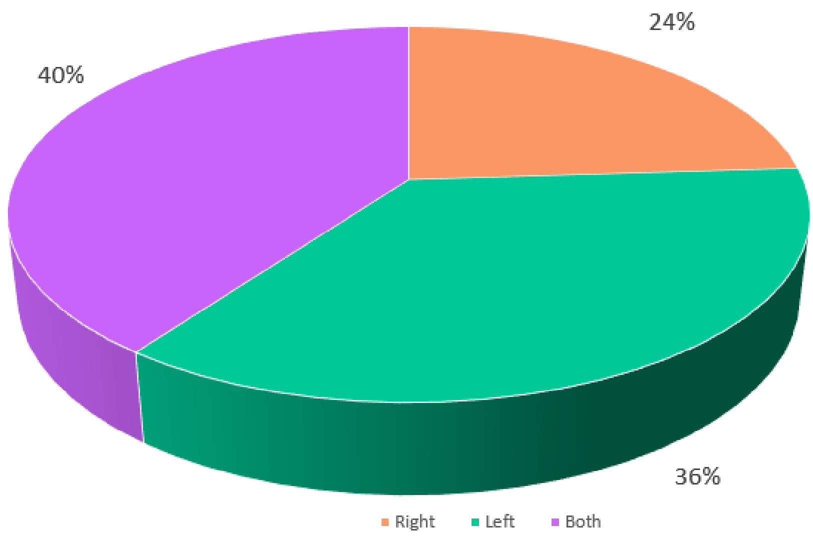

Figure 17: Laterality

The number of hours spent in sunlight per day is positively correlated with the length of the pterygium. Both the length and base of the pterygium also correlate with the amount of

astigmatism measured by both manual keratometry and Scheimpflug imaging. Also the lengthofthe pterygium correlated positively with the duration of the pterygium.
The amount of astigmatism measured in our patients represents the naturally occurring atigmatism plus the induced effect of the pterygium. Correlation between these two can only be estimated when the pterygium has been removed surgically and the corneal topography done post operatively.

CONCLUSION

The amount of astigmatism induced by a pterygium determines its effect on visual acuity and also plays an important role in decision making on surgical removal. The problem with using standard keratometers is that they are completely blind tothe central cornea, measuring insteadanintermediate zone andextrapolating acentral value thuscangive erroneous readings in patients with large pterygium. Scheimpflug imaging maintains the central point in each meridian when it takes image slices of the cornea, hence eliminating inaccuracies due to eye movement. In our study, the length of the pterygium was also positively correlated with the amount of astigmatism measured. This was also noted by Lin and Stern [52] who found a significant correlation between the pterygium size and cornealastigmatism.
Pentacam was an effective tool, to measure the amount of astigmatism even in those patients where manual keratometry was not possible duetodistortionofmires. The Pentacam goes beyond topography and pachymetry and enablesa3-dimensionalcornealreconstruction,whichposterior curvatures andcreatesa metric map which is of immenseuseinquantifying and evaluating the effect of a pterygium on astigmatism and as a consequence on visual acuity.
However, since this study does not take into account pre-existing astigmatism of patients,itcanbea confounding factor in accurate analysis of results. A larger series of patients measuring quantumofastigmatismpre and post-surgical removal of pterygium will allow a more accurate measurement of astigmatism induced by a pterygium.
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CONFLICT OF INTEREST

The authors declare no conflict of interest

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