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Original Research Article

A STUDY ON COMPARISON BETWEEN KERATOCONUS EYES AND NORMAL EYES USING SIRIUS DEVICE IN A TERTIARY CARE CENTRE

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ABSTRACT

Background: Keratoconus is bilateral ectatic corneal condition wherein the cornea bulges out in form of cone. Detecting early keratoconus is important to prevent permanent damage. The purpose of this study is to measure the various parts and surfaces of the anterior segment of eye using a Scheimpflug rotating camera in combination with a Placido disk tomography to differentiate eyes with keratoconus and normal eyes.

Materials and Methods:100 patients comprising of 50 patients with normal eyes and 50 patients with keratoconus were included in this study which was conducted over 1 year in the Department of Ophthalmology. All patients were subjected to scanning by the Sirius Device and measurements were analyzed for differences.

Results: Excellent AUROC values were observed in 19 of 24 parameters (K-flat anterior; K-steep anterior; Astigmatism anterior; Asphericity anterior;K-max; K-flat posterior; K –steep posterior; Astigmatism posterior; Asphericity posterior; K- mean posterior; CCT; Si-F; KV-F; BCV-F; Si-b; KV- B; BCV-B; Rbf-f; Rbf- b). Corneal volume measurement was an inefficient parameter; ICA and ACD are poor parameters to differentiate keratoconus from normal eyes.

Conclusion: The thickness indices (CCT); aberrometry indices – BCV-f, BCV-b; and elevation indices Rbf-f,Rbf-b are excellent indices to differentiate between keratoconus and normal eyes.

Keywords: Keratoconus, Placido disk, Scheimpflug camera, Sirius device, cornea.

INTRODUCTION

Keratoconus is derived from combination of Greek words namely, keras = cornea &conus = cone. It is characterized by progressive ectasia of the cornea wherein the cornea configures cone like structure leading to irregularities in corneal stroma, thinning of the corneal membrane and ultimately visual loss.[1-3] Keratoconus typically manifests in adolescence period progressing upto to the fourth decade and has a worldwide prevalence of 50-230 per 1,00,000 population.[4,5]Keratoconus has a strong genetic predisposition with the risk of acquiring the disease in siblings being upto 6-8%. It is predominantly associated with syndromes such as Down's (0.5-15%), Leber's congenital amaurosis (30%) and mitral valve prolapse (58%).[6-8]

Evaluation in patients with Keratoconus involves initial refractory power of the patient's cornea followed by corneal imaging tools such as slit-lamp bio-microscopy, corneal topography and corneal tomography.[9]

Topography can detect subtle surface irregularities of the cornea even before occurrence of clinical signs and also in patients with normal slit lamp examinations. Corneal topography using Placido disk was first pioneered by Amsler in the 19th century.[10] With the advent of combination of Scheimpflug rotating camera along with Placido disk topography (Sirius device), one not only is able to visualize and measure the structures in anterior segment of the eye, but can also measure the posterior surface of the cornea and provide pachymetric maps of the same.[11]

In this study we aim to analyze the anterior and posterior surfaces of cornea, Keratoconus indices, corneal thickness profile, and data from pachymetry maps of corneas with and without Keratoconus using the Sirius device (Scheimpflug camera with Placido disk based corneal tomography), and also to assess the sensitivity and specificity of these parameters in detecting subclinical keratoconus.

MATERIAL AND METHODS

This retrospective observational study was conducted in the Department of Ophthalmology, Mallareddy Medical college for women over a period of 12 months, i.e., from April 2023 to March 2024. Ethical committee approval was taken prior to beginning of the study. Written informed consent was taken from all the patients after explaining them regarding the procedure and were included in the study only after their approval.

Inclusion Criteria: Patients diagnosed with keratoconus using the standard protocol (asymmetrical bowtie pattern on corneal tomography with or without skewed radial axes along with presence of at least one of the following on slit lamp examination – stromal thinning, corneal conical protrusion, presence of Fleischer ring, presence of Vogt striae, presence of any anterior stromal scars).

Exclusion Criteria: Patients with other ocular pathology, xerophthalmia, presence of corneal scarring, history of ocular surgery or collagen cross-linkage or keratoplasty, history of corneal hydrops, corneal infections, glaucoma, pregnant or lactating women, history of usage of contact lens within 7 days and patients on any topical ocular medications.

All patients underwent routine ocular examination which included testing for visual acuity, slit lamp examination and fundus examination.

Eyes were considered normal if they had no evidence of ocular pathology or any evidence of corneal abnormalities.

Procedure: A comprehensive corneal examination was done using the Sirius device which integrates a rotating Scheimpflug camera along with Placido disk corneal topography. A monochromatic slit-light source is used to gather anterior segment topography data. The Sirius device offers extensive corneal topographic, tomographic, and pachymetric data.

Patients were explained regarding the procedure and were taken into a dark room for examination to acquire a reflex free image. All measurements were taken by a well-experienced optometrist. The patient's eye was aligned along the visual axis by asking them to fix their eyes on the black target of central fixation beam. Patients were asked to blink in between to prevent drying up of eyes. Artificial tear drops were used whenever it seemed necessary.

Images were acquired automatically, with a 180° rotation capturing 25 slit images to create a 3D model of the anterior segment of eye. All patients were subjected to scanning and the the quality of image, alignment, anterior and posterior coverage and topography were critically reviewed. Only scans with a quality factor (QS) above 95% were saved. In case of apoor quality scan, a repeat scan was done. All measurements were done according to the manufacturer's guidelines by an expert examiner who was blinded to the diagnosis.

Key parameters recorded included keratometry readings, topographic astigmatism, cornea asphericity, pachymetry, cornea volume, and anterior chamber details. Corneal thickness was measured at the thinnest point, and corneal volume within a 10 mm diameter around the corneal apex. Anterior chamber depth was from the corneal endothelium to the lens capsule, while volume was calculated from the endothelium down to the iris and lens over a 12 mm diameter. The smallest anterior chamber angle in the horizontal position was also noted.

Front and back elevation differences were measured using the best fit sphere (BFS) and enhanced BFS from the BAD display software. Parameters like spherical equivalent (SE) values in diopters were derived from cycloplegic refraction, focusing on the central 8 mm of the cornea.

Keratoconus patients' eyes were compared with normal corneas in separate analyses. Data were statistically analyzed using SPSS version 16.0, with ROC curves assessing the test's predictive accuracy through the area under the curve (AUROC), sensitivity, specificity, accuracy, and cutoff values. AUROC values closer to 1 indicated better discrimination, with categories being - excellent (0.9-1); good (0.8-0.9); fair (0.7-0.8); poor (0.6-0.7) to very poor (0.5-0.6) performance. Value of <0.5 is suggestive of inefficient measure.

RESULTS

A total of 200 eyes of 100 patients were examined in the study, 50 patients with normal eyes and 50 patients with bilateral keratoconus. The mean age of patients with normal eyes was 30.85 years (range = 12 years to 60 years) and that of patients with keratoconus is 33.54 years (range = 15 years to 75 years). Male to female ratio in patients with normal eyes is 2.3:1 (males = 35; females = 15) and that in patients with keratoconus is 2.1:1 (males = 34; females = 16). The mean spherical refraction of normal eyes was -0.84D.

Comparison was done of all the parameters between eyes with keratoconus and that of normal eyes. All of the parameters were significantly deranged in patients with keratoconus except for difference between iris-cornea angle and depth of anterior chamber which was not significant.

Out of all the 24 parameters measured, 18 parameters had AUROC values between 0.9-1 suggestive of parameters with excellent sensitivity and specificity in differentiating between normal eyes and those with keratoconus (K-flat anterior AUROC – 0.99; K-steep anterior AUROC – 1; Astigmatism anterior AUROC – 1; Asphericity anterior AUROC – 1; k-max AUROC – 0.99; K-flat posterior AUROC – 0.97; K –steep posterior AUROC – 0.95; Astigmatism posterior AUROC – 1; Asphericity posterior AUROC – 1; K- mean posterior AUROC – 0.97; CCT

AUROC – 1; Si-F AUROC – 0.9; KV-F AUROC – 1; BCV-F AUROC – 1; Si-b AUROC – 0.9; KV- B AUROC – 1; BCV-B AUROC – 1; Rbf-f AUROC -0.98; Rbf- b AUROC – 0.98).

In present study, Corneal volume (CV) seemed to be an inefficient parameter in differentitating between keratoconus and normal eyes (CV AUROC – 0.24).

While measurement of K-mean of anterior corneal surface and depth of anterior chamber have fair sensitivity and specificity (K-mean anterior AUROC – 0.6; ACD AUROC – 0.7); measuring anterior chamber volume and iris-corneal angle have poor sensitivity and specificity (ACV AUROC – 0.55; ICA AUROC – 0.50) in differentiating between eyes with keratoconus and normal ones. [Table 1]

Table 1: Measurements of various parameters in patients with and without keratoconus

Parameter	Keratoconus Mean ± SD(range)	Normal Mean ± SD(range)	P value
K-flat (anterior)	47.84 ± 1.57	44.1± 1.50	<0.001
K-steep (anterior)	54.13 ± 2.95	43.12 ± 1.78	<0.001
K-mean (anterior)	45.01 ± 0.01	44.28 ± 1.02	<0.001
Kmax	55.10±7.84	44.94±2.54	<0.001
Astigmatism (anterior)	−0.94±0.32	1.24±0.78	<0.001
Asphericity (anterior)	−6.97±0.84	−0.45±0.22	<0.001
K-flat (posterior)	7.54 ± 1.54	6.12 ± 1.02	<0.001
K-steep (posterior)	8.47 ± 1.67	6.34 ± 0.13	<0.001
Kmean (posterior)	7.87 ± 1.05	6.42 ± 0.62	<0.001
Astigmatism (posterior)	0.79 ± 0.48	0.34 ± 0.71	<0.001
Asphericity (posterior)	-0.91 ± 0.25	0.33±0.51	<0.001
Central corneal thickness (CCT)	4321.17 ± 45.32	545.17 ± 41.25	<0.001
Corneal volume (CV)	53.71 ± 4.05	58.61 ± 3.17	<0.001
Anterior chamber volume (ACV)	194.54 ± 30.69	180.30 ± 32.57	<0.001
Iris- cornea angle (ICA)	46.21 ± 5.01	44.12 ± 7.18	0.4 (not significant)
Anterior chamber Depth (ACD)	3.78 ± 0.47	3.45 ± 0.78	0.347 (not significant)
Symmetry index of front corneal curvature (Si-f)	4.01 ± 1.28	0.23 ± 0.54	<0.001
Keratoconus vertex-front (Kv-f)	31.61 ± 10.24	4.12 ± 2.8	<0.001
BaiocchiCalossiVersaci index - front (BCV-f)	3.41 ± 1.64	0.28 ± 0.30	<0.001
Symmetry index of back corneal curvature (Si-b)	1.24 ± 0.98	–0.06 ± 0.18	<0.001
Keratoconus vertex – back (Kv-b)	88.54 ± 26.41	13.55 ± 3.74	<0.001
BaiocchiCalossiVersaci index - back (BCV-b)	3.21 ± 1.57	0.07 ± 0.23	<0.001
Rbf-f	49.15 ± 1.57	43.87 ± 1.96	<0.001
Rbf-b	58.97 ± 2.19	52.48 ± 2.65	<0.001

Table 2: Receiver-operating-characteristiccurveanalysisofparametersbetween keratoconus group andnormalgroup

Variables	AUC	Std.Error	95 %CI		Sensitivity	Specificity	Cutoffvalue
			LowerBound	Upper Bound			
K-flat (anterior)	0.99	0.02	0.94	1.00	0.97	0.21	45.71
K-steep (anterior)	1.00	0.00	1.00	1.00	1	0.65	56.81
K-mean (anterior)	0.62	0.04	0.51	0.72	0.62	1	43.67
Astigmatism (anterior)	1.00	0.00	1.00	1.00	1	0.62	55.67
Asphericity (anterior)	1.00	0.00	1.00	1.00	1	0.63	51.57
K-max	0.99	0.007	0.91	0.93	0.893	0.953	47.50
K-flat (posterior)	0.97	0.03	0.87	1.02	0.97	0.27	6.86
K-steep (posterior)	0.95	0.05	0.89	1.05	1	0.28	9.38
Astigmatism (posterior)	1.00	0.00	1.00	1.00	1	0.86	8.58
Asphericity (posterior)	1.00	0.00	0.97	1.00	1	0.42	7.13
K-mean (posterior)	0.97	0.03	0.89	1.03	0.98	0.81	7.47
Central corneal thickness (CCT)	1.00	0.00	1.00	1.00	0.88	0.99	442.18
Corneal volume (CV)	0.24	0.06	0.14	0.34	0.66	0.87	59.87
Anterior chamber volume (ACV)	0.55	0.07	0.47	0.68	0.65	0.66	196.52
Iris- cornea angle (ICA)	0.50	0.06	0.38	0.62	0.84	0.84	50.50
Anterior chamber Depth (ACD)	0.72	0.05	0.61	0.84	0.97	0.78	3.37
Symmetry index of front corneal curvature (Si-f)	0.90	0.07	0.87	1.00	1	0.36	1.23
Keratoconus vertex-front (Kv-f)	1.00	0.00	1.00	1.00	1	0.86	48
BaiocchiCalossiVersaci index - front (BCV-f)	1.00	0.00	1.00	1.00	0.98	0.33	2.62
Symmetry index of back corneal curvature (Si-b)	0.94	0.05	0.87	1.03	1	0.62	1.34
Keratoconus vertex – back (Kv-b)	1.00	0.00	1.00	1.00	1	0.62	93
BaiocchiCalossiVersaci index - back (BCV-b)	1.00	0.00	1.00	1.00	1	0.88	4.14

Rbf-f	0.98	0.01	0.99	1.00	1	0.99	51.43
Rbf-b	0.98	0.01	0.99	1.01	1	0.34	53.79

DISCUSSION

In present study, 24 parameters were analyzed to differentiate keratoconus from normal eyes using Sirius device. Out of the 24 parameters, 22 parameters were significantly different in eyes with keratoconus than normal eyes. The ICA & ACD were different as well, but were not statistically significant. ROC analysis was done to determine sensitivity and specificity of different parameters and determine cut-off values. Out of the 24 parameters, 18 parameters had excellent AUROC values. In present study, CCT and Kv-f were found to have the highest AUROC values with highest sensitivity and specificity. The cut-off value of 442 microns for CCT had 88% sensitivity and 99% specificity.

In a study done by Orucoglu et al [12] K-max and thinnest corneal thickness showed the highest sensitivity and specificity. The cut-off values for corneal thickness ranged between 489-493 in different other studies.[13,14]

In study done by Smadja et al,[15] they observed that the best-fit toric and aspheric reference surface for calculating elevation were better parameters for differentiating between keratoconus eyes and normal eyes.

Safarzadeh et al,[16] compared the anterior segment parameters in normal eyes and keratoconus eyes of 255 patients. Patients with keratoconus were grouped based on the severity of keratoconus into suspect, mild, moderate and severe. According to their study, posterior corneal elevation, corneal thickness and high aberrations are the most promising indices to differentiate between keratoconus and normal eyes.

Ghareib et al,[17] compared keratoconus suspects and forme-frustekeratoconus (FFKC) using combined PlacidoScheimpflug topography. In their study, Kv-f and Kv-b had the highest AUROC values.

CONCLUSION

The study concludes that Sirius device had almost good sensitivity and specificity for detecting keratoconus even in the early stage, i.e. even before the onset of Vogt striae and clinical symptoms. The precision can be improved further by conducting this study over a larger population so that the results can be generalized.

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