# Prevalence of Keratoconus and subclinical keratoconus in Indian population with Astigmatism more than Two Diopters by Pentacam: A Cross-Sectional Study

**Dr.Harsimran Singh[1], Dr. Anil Pathak[2], Dr.Subah Mahajan[3], Dr. Akash[4], Dr.Dipak Narwade[5]**

[1]Professor and unit 2 Head, Department of Ophthalmology, Government Medical College, Patiala
[2]Associate Professor, Department of ophthalmology, Government Medical College, Patiala
[3]Senior Resident, Department of ophthalmology, Government Medical College, Patiala
[4]Junior Resident, Department of ophthalmology, Government Medical College, Patiala
[5]Senior Resident, Department of ophthalmology, Government Medical College, Patiala

Corresponding author- Dr.DipakNarwade (Senior Resident, Government Medical College, Patiala)

**ABSTRACT:**
**Context:**
Keratoconus is non-inflammatory, asymmetrical, bilateral, and ectatic disease of the cornea.[1] The diagnosis of advanced KCN can be easily made because of its characteristic topographic and biomicroscopic findings, but identification of subclinical cases may be extremely challenging. Detection of subclinical cases is important prior to refractive surgeries as it can aggravate the progression of ectasia. [6]
**Aims:** The present study was aimed at investigating the prevalence of keratoconus and subclinical keratoconus in Indian population with astigmatism more than 2 D by Pentacam derived parameters and comparison of parameters among these groups.
**Settings and Design**: In this cross-sectional study, 50 patients (100 eyes) with astigmatism >2D who were referred to the Outpatient Department of Ophthalmology in Government Medical College Patiala were recruited.
**Methods and Material:**All of the patients underwent a complete ophthalmic examination including refraction, retinoscopy, visual acuity, slit lamp biomicroscopy, posterior segment examination and corneal topography with Pentacam.
**Statistical analysis used:**The collected data were analysed using Mann-Whitney U Test using SPSS version 20.0.
**Results:**Mean age of the study population was $27\pm6.7$ (range 16-45) years ofwhich 24 (52%) were female and 26 (48%) were male subjects. In this present study, 6% of patients with astigmatism >2D had keratoconus and 9% had subclinical keratoconus.
**Conclusions:**
Maximum keratometry, index of surface variance, index of vertical asymmetry, keratoconus index and anterior and posterior elevation values were significantly higher and thinnest pachymetry was significantly lower in eyes with clinical or subclinical KCN than normal astigmatic eyes ($P< 0.05$).
Key-words: Astigmatism; Corneal Topography; Keratoconus; Pentacam; Scheimpflug; Subclinical Keratoconus.
**Key Messages:**The current study showed that subjects with 2D or more of astigmatism should undergo corneal topography screening for early diagnosis of KCN even if visual

acuity is not affected. These patients can be kept on frequent follow up for detection of progression.

## Introduction:

Keratoconus is non-inflammatory, asymmetrical, bilateral, and ectatic disease of the cornea.(1) Keratoconus is derived from Greek words,Kerato means cornea and Konos means cone.

The incidence of keratoconus is approximately 1 per 2,000 in the general population [6] and prevalence of keratoconus in India is 2.3%.(2)

Keratoconus develop at a young age, usually in the twenties and affects both gender.(3) Keratoconus is a progressive disease; it progresses until the age of 40 and then stabilizes.(4) Keratoconus usually progresses from unilateral to bilateral over an average duration of 16 years. Keratoconus shows no gender predilection. (5) Patients present with history of progressive loss of vision with ghost images, frequent changing of spectacle correction with unsatisfactory results, and ocular allergies with frequent eye rubbing. Thinning of the cornea induce irregular astigmatism, myopia, and protrusion, which causes a mild to the marked decrease in quantity and quality of vision.(6) In more advanced cases, corneal edema causes scarring and decompensation of the cornea that further reduces visual acuity.

The diagnosis of subclinical keratoconus is mandatory before any refractive surgery. Subclinical keratoconus is preclinical stage of KCN that can only be detected by corneal topography and not by slit lamp examination.

The term subclinical KC describes the very early preclinical stage of KC that can only be detected using diagnostic examinations such as corneal topography. There are so many different methods to distinguish eye with keratoconus from the normal eye, but theylack specific criteria to differentiate subclinical KCN eyefrom normal eye.

The Pentacam is the most commonly used commercially available system for evaluation of subtle changes in the cornea. Pentacam is one of the imaging techniques used for scanning anterior and posterior corneal surface which are essential for diagnosingsubclinical keratoconus. Its repeatability and reproducibility of corneal thicKCNess and posterior elevation measurements has been reported to be high. (7)

## Subjects and method

In this cross-sectional study subjects of age 15 to 45 years attending Outpatient department for routine check-up with astigmatism 2D or more were included. Subjects with other ocular diseases and pregnant ladies were excluded. All Subjects underwent refraction, retinoscopy, slit lamp examination, corneal topography and fundus examination.

An eye was diagnosed with keratoconus when scissoring reflex was present on retinoscopy and topography showed central or paracentral steepening of cornea with any signs on slit lamp examination, which includes corneal thinning, protrusion, Vogt striae, Descemet's break, Fleischer ring, apical scarring and subepithelial fibrosis. An eye was diagnosed with subclinical keratoconus if other eye had keratoconus or there was inferior-superior asymmetry or bow-tie pattern with skewed radial axes detected on tangential maps on topography with no other signs. Subjects with no abnormality detected on topography were labelled as normal astigmatic group.

The subjects were asked to place his/her chin on the chin rest and the forehead against the head rest. And fix the eye on  internal target during measurement without any compensation for their refractive error. Automatic mode of the instrument was used, in which image capturing starts when correct alignment with the corneal apex and focus is achieved. Only those scans with examination quality registered as "OK" were included. This insured

that scans were not affected by poor fixation, misalignment or missing segments. We focused and aligned real-time image of the patient's eye on the computer monitor, with the machine marking the pupil edge, centre and the corneal apex. The automatic release mode was used to decrease operator dependent variables. It has a quality check in the form of quality factor (QS) both for image analysis of the anterior and posterior corneal surface. Only scans with quality factor „OK" were saved. From the Pentacam examination, flat keratometry (K1) and steep keratometry (K2) readings, maximum simulated keratometry (Kmax), corneal thicKCNess at the thinnest point of the cornea (minimal pachymetry), keratoconus index (KI), index of surface variance (ISV), index of vertical asymmetry (IVA), anterior elevation (AE) and posterior elevation (PE) were recorded into an Excel worksheet.

The data were collected from patients using a case report form. Data was entered in excel and analysed. Student t test and Wilcoxon Rank Sum test (Mann-Whitney U Test) was used for assessment of level of significance. P- value of less than 0.05 was taken as significant

**Results**

One hundred eyes of 50 subjects were included in this study. Mean age was 27±6.7 (range from 15 to 45) years.The study population included 24 (48%) female and 26 (52%) male subjects. 64 of eyes had a visual acuity of 6/18 while only 4 eyes had visual acuity of 6/60 to FC. The presenting visual acuity was found to improve with spectacles as 56 eyes achieved visual acuity of 6/6 while only 4 eyes had visual acuity of 6/60 to FC.

Pentacam measurements yielded mean K1, K2 and Kmax of 43.17±4.66 D, 45.61±5.07D and 45.78±4.94D respectively. Mean minimal pachymetry value was 515±44 μm, mean ISV was 26.59±14.78, mean IVA was 0.15±0.17 and mean KI was 1.02±0.04. Mean AE and PE were 4.03±6.25 μm, 7.6±12.4 μm respectively. From the entire study sample, 6 eyes (6%) were diagnosed with KCN and 9 eyes (9%) as subclinical KCN. Out of 7 patients with KCN and subclinical KCN, 3 were female and 4 were male; 2 patients had bilateral KCN, 3 patients had bilateral subclinical KCN and 2 patients had KCN in one eye and subclinical KCN in another eye. Mean age was 27±6.7 years in patients with KCN, 28.2±4.2 years in patients with subclinical KCN and 28.0±6 years in astigmatic patients. There were no statistically significant differences in spherical and cylindrical refractive error among KCN, subclinical KCN and astigmatic eyes (P > 0.05, for all comparisons). There were statistically significant differences between KCN eyes and astigmatic eyes in all Pentacam parameters except for cylindrical refractive error (P<0.001) With the exception of K1, K2, Kmax, cylindrical error and ISV value, statistically significant differences were found in all parameters between subclinical KCN eyes and astigmatic eyes (P<0.05). Mean minimal pachymetry was 446.5±31 μm in KCN eyes, 492±29 μm in subclinical KCN eyes and 525±41 μm in astigmatic eyes (Figure 1). Mean anterior elevation was 24.67±13.99 μm, 5±1.32 μm and 2.24±1.64 μm, respectively. Mean posterior elevation was 47.5±28.19 μm, 13.33±3.61 μm, 3.25±3.78 μm, respectively. The distributions of anterior and posterior corneal elevations are presented in Figure 2 and 3 respectively.

**Table 1. Mean values for Pentacam parameters by study group**

| Parameter | Mean±Standard Deviation | | | |
|---|---|---|---|---|
| | Astigmatism | Subclinical Keratoconus | Keratoconus | P Value |
| K1 (D) | 42.97±4.91 | 42.85±1.70 | 45.7±2.45 | 0.726/0.0033* |
| K2 (D) | 45.37±1.25 | 45.08±1.73 | 50.02±6.24 | 0.138/0.001* |
| Kmax (D) | 45.62±1.38 | 45.35±1.92 | 50.37±3.77 | 0.222/0.005* |
| Cylinder (D) | 2.41±1.01 | 2.23±0.65 | 4.28±07 | 0.293/0.483 |

| Thinnest Pachy (µm) | 525.62±41.16 | 492±28.59 | 446.5±31.36 | 0.007*/0.0001* |
|---|---|---|---|---|
| ISV | 26.44±6.08 | 27.66±5.05 | 70.67±37.12 | 0.674/0.0001* |
| IVA | 0.15±0.07 | 0.2±0.02 | 0.66±0.44 | 0.008*/0.00008* |
| KI | 1.01±0.025 | 1.04±0.01 | 1.19±0.17 | 0.00001*/0.00252* |
| Anterior Elevation (µm) | 2.24±1.64 | 5±1.32 | 24.67±13.99 | 0.00006*/0.00001* |
| Posterior Elevation (µm) | 3.25±3.78 | 13.33±3.61 | 47.5±28.19 | 0.00001*/0.00001* |

Figure 1.Comparison of mean and standard deviation of minimum pachymetry (µm) of cornea between astigmatism, subclinical keratoconus and keratoconus groups
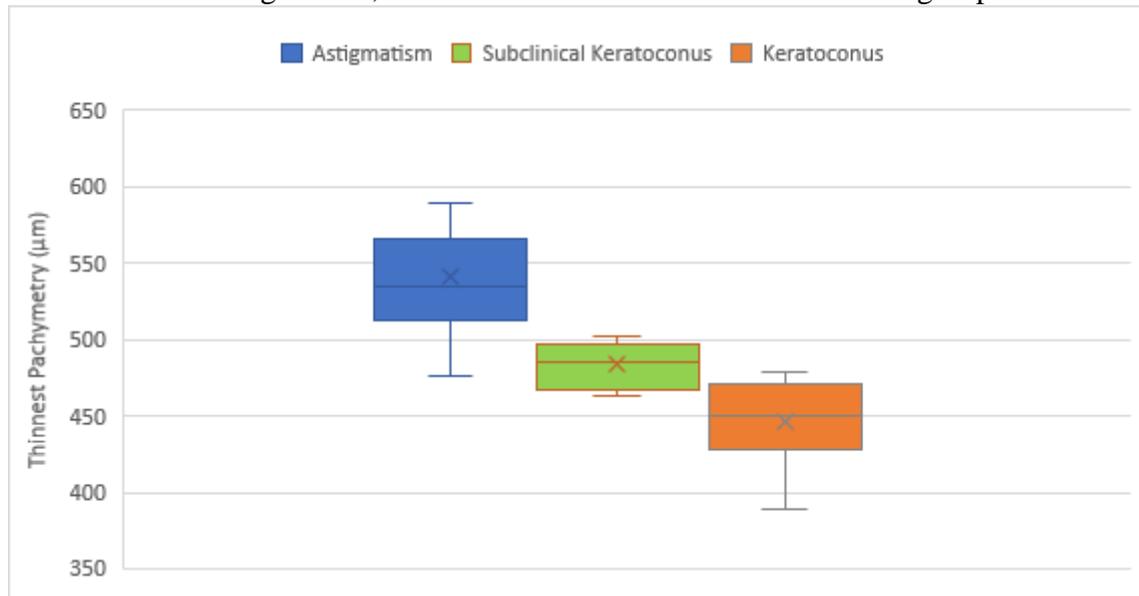


Figure 2.Comparison of mean and standard deviation of anterior elevation (µm) of cornea between astigmatism, subclinical keratoconus and keratoconus groups
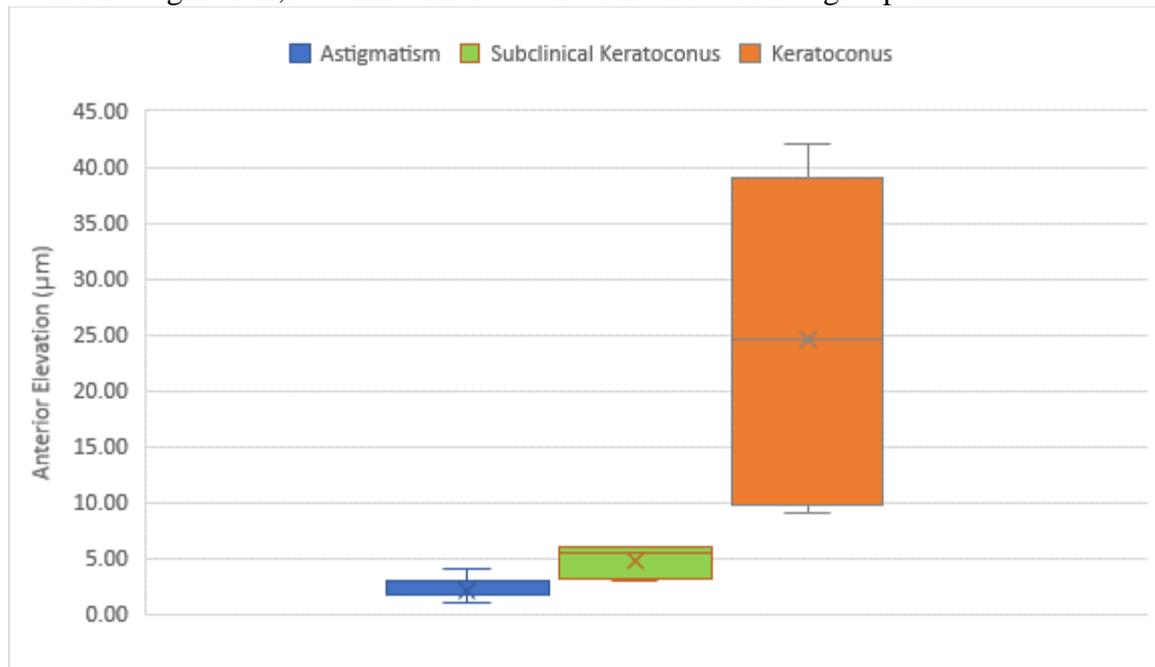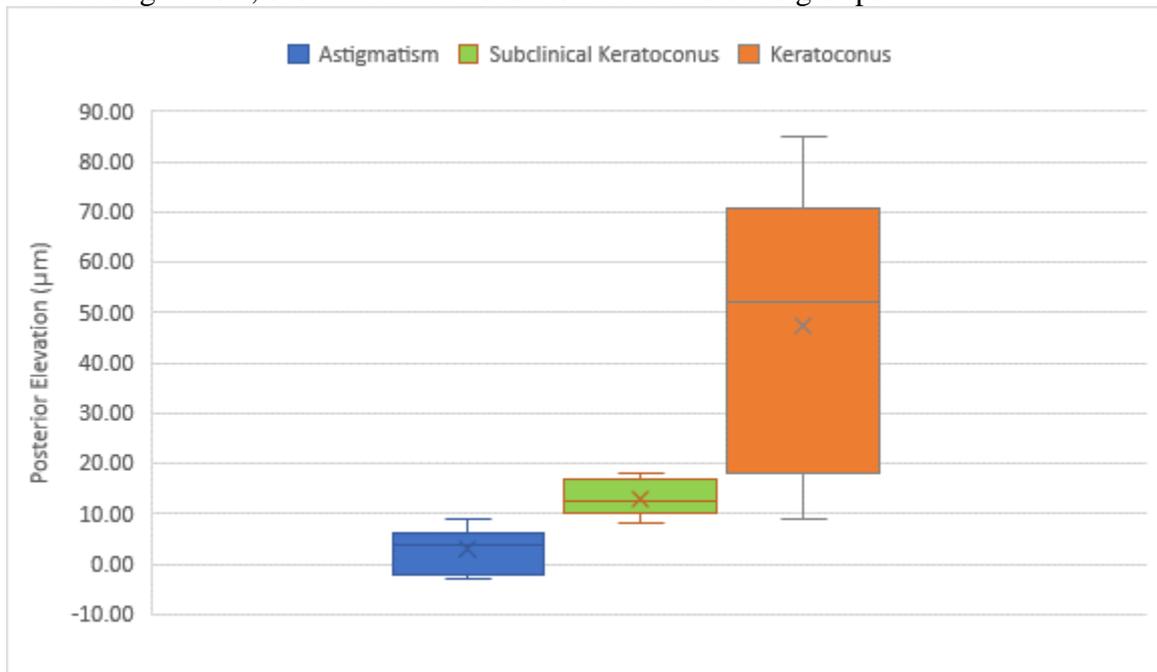
Figure 3.Comparison of mean and standard deviation of posterior elevation (μm) of cornea between astigmatism, subclinical keratoconus and keratoconus groups



**Discussion**-

The prevalence of keratoconus is different in different countries due to geographical changes and environmental factors. The incidence of keratoconus is approximately 1 per 2,000 in the general population.(6) A study done in Central India by Jost B Jonas et al, displayed the prevalence of keratoconus is 2.3%.(2) The population-based study done by R H Kennedy et al in Minnesota using a Placido disc reported an incidence of 600 per 100,000. Keratoconus affects both men and women, while it is not clear whether significant difference between them exist. Some studies found it to be more common in males and some in females.(8) Ethnic differences may affect the prevalence of keratoconus. The results of two surveys done in the UK suggest that the prevalence of keratoconus is higher in the Asian population as compared to Caucasians.(9,10) Most of the keratoconus (KC) cases are sporadic; however, 6–23.5% of patients have a positive family history.(11) First-degree relatives of KCN patients have a risk of developing KCN 15–67 times more than the general population.(12)

Pentacam can obtain 50 Scheimpflug images in 2 seconds. Each image of Pentacam has 500 true elevation points and total corneal surface has 25,000 true elevation points. The HR Pentacam can generate 138,000 elevation points at the same time. The Pentacam is unique because it derives its primary data from elevation maps.(13) and evaluates both anterior and posterior corneal surfaces.(14)Pentacamprovide more repeatable and reproducible measurements as compare to placido disc-based topography in keratoconic and post-Lasik corneas. (15)

Keratoconus is diagnosed easily on slit-lamp examination but diagnosis of subclinical keratoconus is not possible. As in subclinical cases slit lamp examination remains normal and visual acuity may not affect. Pentacam corneal curvature and pachymetric indices help to diagnose the subclinical cases of KCN. (16) In Study by Hashemi et al found that ISV and IVA indices have higher predictive power in diagnosis of subclinical keratoconus. ISV and IVA more than 22 and 0.14, respectively used as criteria for diagnosis of subclinical KCN

cases. In our study mean ISV and IVA in subclinical cases were 27.66±5.05 and 0.2±0.02, respectively which was statistically higher than normal astigmatic subjects (P<0.05).

In a study bySerdarogullari et al,(17)  128 eyes of 64 subjects with astigmatism ≥2D were studied. The prevalence of KC and subclinical KC was 6.3% (8/128) and 7.8% (10/128) respectively. Bilateral KC was found in 3 patients, subclinical KC in 4 patients and 2 patients with KC in one eye and subclinical KC in another eye. They found that prevalence rate of keratoconus increases as cylindrical power increase.

In a study by Lim et al  (18) the values of maximum posterior elevation and corneal thinnest pachymetry were significantly differ in both KC and KC suspect group compare to normal control group. These findings were consistent with our study.

In the study by Syed Sadaf Altaf,(19)  13.2% of patients with astigmatism >1.5D had keratoconus. Among them 13 patients had bilateral keratoconus (76.5%) while 4 patients had unilateral keratoconus (23.5%). They found that statistically significant differences between keratoconus eyes and astigmatic eyes in video keratographic parameters (P value<0.05).

In the study by Ucakhan et al (20), they showed that several Pentacam indices like anterior and posterior corneal power and elevation and pachymetric indices, are helpful in differentiating eyes with subclinical and clinical KCN from normal eyes. They found that posterior elevation data is more significant for differentiating subclinical KCN eyes from normal eyes and anterior elevation data for KCN eyes. Combined indices of Pentacamare betterthan single parameter for diagnosing different stages of KCN.

In a study conducted by Mihaltz K (21), all Pentacam parameters were significantly different in keratoconus group compared to normal control group. ROC curved analysis showed that anterior and posterior elevation indices have best predictive accuracy value followed by minimal and central pachymetry. The cut off value of posterior elevation was 15.5 μm for differentiation of keratoconus eyes from normal eyes. Most significant parameters for KCN diagnosis were minimal pachymetry, anterior elevation and keratometry.

Based on Pentacam topographic map, Vejarano(22) stated that KCN should be suspected in eyes with anterior elevation more than 15 μm and posterior elevation more than 20 μm, thinnest pachy less than 500 μm, and keratometric power more than 47D on tangential map when analyzed at thinnest point. Eyes anterior elevation 12 to 15 μm, posterior elevation 15 to 20 μm with thinnest pachymetry point less than 500 μm at the thinnest point were diagnosed as KCN suspects.

In our study topographic indices from Pentacm K1, K2, Kmax, thinnest pachy, ISV, IVA, KI, AE, PE were statistically different from KCN group and astigmatism group. Thinnest pachy, IVA, KI, AE and PE indices were significantly different between subclinical KCN and Astigmatism group. Thinnest pachy, AE and PE indices were highly significant for differentiating eyes normal from keratoconus. In our study population 2 subjects had bilateral keratoconus (4%), while 2 had unilateral keratoconus (2%), 2 (4%) had bilateral subclinical KCN and 5 (5%) had unilateral KCN. The prevalence of keratoconus was 6% (6 eyes). Since this study is limited by sample size, our results may not reflect the actual prevalence of keratoconus in the population >2D astigmatism. It was found that with increasing cylinder power there was higher prevalence of KCN. Our study showed that Pentacam is useful in differentiating normal astigmatic eyes from subclinical KCN. It has found that anterior elevation, posterior elevation and thinnest pachymetry are most significant indices for differentiating subclinical KCN eyes from normal eyes. The prevalence was higher as compare to other studies because Pentacam provides more accurate diagnosis of keratoconus. Therefore, it is important to examine all subjects with higher stigmatism with Pentacam for early detection of keratoconus, treatment and follow up.

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