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Prevalence And Pattern Of Keratoconus In Adult Population In Aswan Governorate

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Abstract

Background: Keratoconus (KC) is a progressive corneal ectasia that causes thinning, steepening, and irregular astigmatism, with variable prevalence across ethnicities and geographic regions.
Objective: To assess the prevalence and pattern of KC in adults in Aswan Governorate and compare findings between Nubian and non-Nubian populations.
Methods: This community-based cross-sectional study included 976 participants aged 18–30 years from randomly selected Nubian and non-Nubian villages. Participants underwent visual acuity testing, auto-refraction, cycloplegic refraction, slit-lamp examination, and corneal tomography (Pentacam). KC was diagnosed based on corneal topography and tomography, and classified by Amsler–Krumeich criteria. Demographic, medical, and family history data were recorded. Statistical analysis was performed using SPSS 25, with $p < 0.05$ considered significant.
Results: KC was identified in 93 participants, yielding an overall prevalence of 9.5%. Prevalence was higher among Nubians (11.9%) than non-Nubians (8.6%). Astigmatism was the most common refractive error in KC eyes, followed by myopia, with significant ethnic differences in distribution ($p < 0.001$). KC prevalence increased with age and was significantly associated with positive medical history ($p = 0.046$) and family history of KC. Most cases were early-stage (Stages 1–2), and corneal thickness decreased progressively with KC severity. Nubian eyes exhibited greater posterior corneal elevation and decentration.
Conclusion: Keratoconus is highly prevalent in young adults in Aswan, with notable ethnic variations in corneal morphology and refractive patterns. Early detection and targeted screening are essential, particularly in populations with higher genetic susceptibility.

Keywords: Keratoconus, Prevalence, Astigmatism, Ethnicity

Introduction

Keratoconus (KC) is the most prevalent kind of primary ectasia. It typically affects patients in the second decade of life and affects all ethnicities and both sexes (1).
KC is asymmetric and bilateral, causing the cornea to gradually thin and steepen. This leads to irregular astigmatism and decrease of visual acuity (2).
The prevalence and incidence of KC varies with regard to ethnicity and geographical location. The process underlying the development of KC is still not fully understood. It has long been believed that KC has a genetic component. There is a correlation between many environmental and familial factors and an increased risk of acquiring KC. Usually, KC affects both eyes although with different degrees of severity (3).
Mild cases can be treated with spectacles and regular follow up, moderate cases with contact lenses. Severe cases can be treated with corneal surgery. Corneal cross-linking is recommended to prevent the progression of keratoconus (4).

For KC to be effectively managed and treated, early screening and identification are essential. A number of screening techniques, including genetic testing, corneal biomechanics, and corneal topography, are being developed to identify KC at early stage. The cornerstone of managing KC is preventing its advancement after it has been diagnosed (5).
This study aimed to assess the prevalence and pattern of keratoconus in adult population in Aswan governorate and compare the prevalence and pattern of KC between Nubian and non-Nubian population.

Patients and methods
This community-based cross-sectional study was conducted on 976 participants between November 2023 and December 2024 in randomly selected Nubian and non-Nubian villages across the governorate.

Inclusion Criteria: Age between 18 and 30 years and residence in selected Aswan villages
Exclusion Criteria: Participants with vernal keratoconjunctivitis, previous refractive surgery or corneal cross-linking, corneal scarring, significant ocular trauma, corneal vascularization or degeneration, syndromic associations (e.g., Down syndrome, Marfan syndrome, Leber's congenital amaurosis), or mental disability.

Sample Size:
The required sample size was calculated using the STATCALC module of Epi-Info statistical package program Version 7.2.5 (CDC 2021, Atlanta, GA, U.S.A) using one population proportion formula for this cross-sectional study design and the following assumptions: Confidence level = 99.9%; Design effect = 1; clusters = 1; Prevalence 28.74 % (6**).** and considering a 10% non-response rate, resulting in 976 participants.

Data Collection and Ophthalmic Examination
After obtaining informed consent, all participants underwent a standardized ophthalmic evaluation that included visual acuity assessment using Snellen's E chart, auto-refraction followed by cycloplegic refraction, slit-lamp examination of the anterior segment, and corneal tomography using the Pentacam HR (Scheimpflug imaging system). In addition, detailed demographic data, medical and ocular history (including atopy, eye rubbing, and family history of keratoconus), refractive parameters, and Pentacam-derived measurements such as keratometry, pachymetry, corneal elevation, and decentration were systematically recorded.

Definitions and Classifications
Refractive errors were defined according to spherical equivalent and cylindrical power, with myopia defined as a spherical equivalent ≤ -0.50 D, hyperopia as a spherical equivalent $\geq +1.00$ D, astigmatism as a cylindrical error ≥ 1.00 D, and emmetropia as a spherical equivalent between -0.50 D and $+0.50$ D. Astigmatism was further classified as with-the-rule, against-the-rule, or oblique based on the axis orientation. Keratoconus diagnosis was established based on abnormal corneal topographic and tomographic findings obtained from Pentacam imaging, and confirmed cases were graded according to the Amsler–Krumeich classification using mean keratometry readings, corneal thickness at the thinnest point, and the degree of refractive error.

Statistical Analysis
Data were analyzed using SPSS version 25. Categorical variables were presented as frequencies and percentages, while continuous variables were summarized using mean ± SD or median (IQR) as appropriate. Comparisons were performed using Chi-square or Fisher's exact test for categorical variables and Student's t-test or Mann–Whitney test for continuous variables. Correlations were assessed using Spearman's coefficient. A p-value < 0.05 was considered statistically significant.

Ethical Considerations
Ethical approval was obtained from the Faculty of Medicine, Aswan University Ethical Committee. Written informed consent was obtained from all participants, and confidentiality was strictly maintained.

Results

Table 1. Baseline characteristics of the study population

Variable	Total Cases=976 (100%) n (%)
Age in years, Mean ± SD (Range)	24.37±4.04 (18-30)
Sex, n (%)	
- Male	419 (42.9)
- Female	557 (57.1)
Residence, n (%)	
- Non-Nubian	699 (71.6)
- Nubian	277 (28.4)
Medical History, n (%)	
Positive	6 (0.6)
Negative	970 (99.4)
Family history of KC	
Yes	12 (1.2)
No	957 (98.8)

☑ Medical history-including atopy, allergy.

The study included 976 participants with a mean age of 24.37 years (SD 4.04, range 18–30), indicating a relatively young adult population. Females comprised a higher proportion of the sample (57.1%) compared to males (42.9%). Most participants were non-Nubian (71.6%), while Nubians represented 28.4% of the group. The vast majority had no significant medical history (99.4%). Only a small fraction (2%) reported a family history of keratoconus (KC). (Table 1)

Table 2. Prevalence of keratoconus among study sample

Keratoconus Status Diagnosis	Total Cases=976 (100%) n (%)
Keratoconus (KC)	93 (9.5)
No KC	883 (90.5)

Keratoconus was diagnosed in 93 out of 976 individuals, showing overall prevalence of 9.5% in the study sample. The vast majority (90.5%) showed no evidence of keratoconus. (Table 2)

Table 3. Baseline Characteristics of The Study Population by Keratoconus Status

Variable	Total Cases=976 (100%)	Keratoconus Status, n (%)		p-val
		Present KC n=93	Absent No KC n=883	
Age Groups				
≤19 years	139	8 (5.76)	131 (94.24)	0.019
20–24 years	355	29 (8.16)	326 (91.84)	
25–29 years	305	30 (9.84)	275 (90.16)	
≥30 years	177	26 (14.69)	151 (85.31)	
Age in years, Mean ± SD	24.37±4.04	25.15±4.0	24.29±4.040	0.052
Gender Sex				
Male	419	40 (9.5)	379 (90.5)	0.987
Female	557	53 (9.5)	504 (90.5)	
Ethnicity				
Non-Nubian	699	60 (8.6)	639 (91.4)	0.110

Nubian	277	33 (11.9)	244 (88.1)	
Medical History¥				
Positive	6	2 (33.3)	4 (66.7)	0.046
Negative	970	91 (9.4)	879 (90.6)	
Family history of KC				
Yes	12	7 (58.3)	5 (41.7)	0.051
No	964	86 (8.9)	878 (91.1)	

Row percent;SD: Standard.Deviation #χ^2 (Chi-square); ⍋ (t-test); Asymptotic Significance (2-sided); ¥: Medical condition present in this study was Diabetes mellitus.
Keratoconus prevalence increased significantly with age (p = 0.019), although mean age did not differ significantly between KC and non-KC groups. KC prevalence was not significantly associated with gender or ethnicity. A positive medical history was significantly linked to higher KC prevalence, while family history showed a higher KC rate but did not reach statistical significance. (Table 3)

Table 4. Association Between Keratoconus Status, Refractive Errors, and Ethnicity

Keratoconus Status	**Refractive Error Type**	**Study groups n (%)**		**Total Eyes** 1952 EYES **n (%)**	**p-value***
		Non-Nubian Eyes	**Nubian Eyes**		
Present (N = 186)	**Emmetropia**	0 (0.0%)	0 (0%)	0	<0.001
	Myopia	120 (8.6%)	66 (11.9%)	186	
	Hyperopia	0 (0.0%)	0 (0%)	0	
	Astigmatism	120 (8.6%)	66 (11.9%)	186	
Absent (N = 1766)	**Emmetropia**	483 (34.5%)	218 (39.4%)	701	0.097
	Myopia	752 (53.8%)	243 (43.9%)	995	
	Hyperopia	43 (3.1%)	27 (4.9%)	70	
	Astigmatism	513 (36.7%)	167 (30.1%)	680	

Column Percentages; - Multiple refractive errors per eye were possible (e.g., an eye could have both myopia and astigmatism), so column totals across error types may exceed 100%. - Since some eyes had multiple refractive errors, the sum of individual error rows may exceed the total number of eyes (186 or 1,766). "Total Eyes" per keratoconus group refers to unique eyes, not the number of refractive error instances. - *p-values compare Nubian vs. Non-Nubian eyes for each refractive error type using χ^2 tests or Fisher's exact tests (for small cell counts). A p-value < 0.05 was considered statistically significant.Refractive Error Definitions: - Myopia: Spherical Equivalent (SE) ≤ -0.50 D;- Hyperopia: Spherical Equivalent (SE) ≥ +1.00 D; - Astigmatism: Reported separately (no SE cutoff specified). --- All keratoconus eyes had refractive errors, exclusively myopia and astigmatism, with a significant ethnic difference in their distribution (p < 0.001). Non-keratoconus eyes showed myopia as the most common error in both ethnic groups, with minor ethnic variations that were not statistically significant (p = 0.097). (Table 4)

Table (5): Quantitative Topographic Parameters in Keratoconus (Nubian vs. Non-Nubian Total Eyes)

Parameter	**Ethnic Study Groups**		**P-Value⍋**
	Nubian Eyes	**Non-Nubian Eyes**	
	(Mean ± SD)	**(Mean ± SD)**	
Flat Keratometry (Kf), D	46.5 ± 3.8	45.9 ± 4.2	0.151
Steep Keratometry (Ks), D	51.2 ± 5.1	50.7 ± 5.4	0.222
K Average, D	48.8 ± 4.5	48.3 ± 4.7	0.183
Thinnest Pachymetry, µm	462.3 ± 48.5	470.1 ± 45.2	0.091

Decentration, mm	-0.7 ± 0.3	-0.6 ± 0.4	0.044
Posterior Elevation, µm	38.5 ± 20.1	35.0 ± 18.3	0.035

⅄Test Used t student test

All keratoconus eyes had refractive errors, exclusively myopia and astigmatism, with a significant ethnic difference in their distribution ($p < 0.001$). Non-keratoconus eyes showed myopia as the most common error in both ethnic groups, with minor ethnic variations that were not statistically significant ($p = 0.097$). (Table 5)

Table (6): Keratoconus Staging Distribution by Ethnic Group (Total: 186 Eyes)

Stage	**Non-Nubian n (%)**	**Nubian n (%)**	**Total Eyes n (%)**	**p-value***
Stage 0	13 (10.8%)	5 (7.6%)	18 (9.7%)	0.161
Stage 1	37 (30.8%)	17 (25.8%)	54 (29.0%)	
Stage 2	37 (30.8%)	23 (34.8%)	60 (32.3%)	
Stage 3	13 (10.8%)	13 (19.7%)	26 (14.0%)	
Stage 4	20 (16.7%)	8 (12.1%)	28 (15.1%)	
Total Eyes	120 (100%)	66 (100%)	186 (100%)	

Each eye was analyzed separately; a single patient may have different stages in each eye; column percentages (distribution of stages within each ethnic group). *p-value calculated by Pearson's Chi-square test for the overall distribution between ethnic groups.

Keratoconus staging was similar between Non-Nubian and Nubian eyes ($p = 0.116$), with Stage 2 being the most prevalent, followed by Stage 1. Advanced stages were less common in both groups, and Stage 0 was the least frequent. Overall, more than 60% of eyes were classified as early to moderate keratoconus (Stages 1–2). (Table 6)

Table (7): Corneal Thickness (µm) by Keratoconus Stage and Ethnicity (N=186 Eyes)

KC Stage	**Total Eyes (%)**	**Ethnicity**	**N (Eyes)**	**Mean ± SD**	**Median (IQR)**	**p-value⅄**
0	18 (9.7%)	Non-Nubian	13	523.5 ± 28.2	525.0 (510-536)	0.413
		Nubian	5	515.2 ± 40.1	516.0 (500-528)	
1	54 (29.0%)	Non-Nubian	37	475.8 ± 33.4	477.0 (450-510)	0.188
		Nubian	17	450.3 ± 45.7	445.0 (437-505)	
2	60 (32.3%)	Non-Nubian	37	448.2 ± 38.9	409.0 (410-475)	0.044
		Nubian	23	420.6 ± 41.2	413.0 (406-478)	
3	26 (14.0%)	Non-Nubian	13	389.1 ± 30.5	388.0 (320-369)	0.029
		Nubian	13	370.7 ± 30.1	375.0 (315-400)	
4	28 (15.1%)	Non-Nubian	20	280.0 ± 42.0	283.0 (220-300)	0.012
		Nubian	8	265.4 ± 40.3	277.0 (205-295)	
Total	186		186			

⅄p-values from Welch's t-test (unequal variances); IQR = Interquartile range (25th-75th percentile)

Corneal thickness decreased progressively with advancing keratoconus stage in both ethnic groups. Non-Nubian eyes showed slightly greater corneal thickness than Nubian eyes, with statistically significant differences emerging from Stage 2 onward, suggesting a possible ethnic influence on disease severity in advanced keratoconus. (Table 7)

Table (8): Correlation Between Cylinder and PentaCam Parameters (Combined Eyes, N = Total Eyes)

Total Eyes:	**Cylinder**	
PentaCam Parameter	**Spearman's rho (ρ)**	**p-value##**

Flat K (Kf)	-0.16	0.006
Steep K (Ks)	-0.51	<0.001
Thinnest Pachymetry	+0.31	<0.001
Decentration	+0.23	<0.001

##Test used: Spearman's rank-order correlation.$p < 0.05$ considered statistically significant.
Corneal thickness decreased progressively with advancing keratoconus stage in both ethnic groups among 186 eyes. Non-Nubian eyes showed slightly higher mean corneal thickness than Nubian eyes at all stages, with statistically significant differences observed at Stage 2 ($p = 0.044$), Stage 3 ($p = 0.029$), and Stage 4 ($p = 0.012$). (Table 8)

Discussion

The mean age of participants in this study was 24.37 years, with a female predominance of 57.1%. Notably, keratoconus prevalence was identical between males and females (9.5% each, p=0.987), indicating no significant gender difference.
Studies by Santodomingo-Rubido et al. (2) and Sarria et al. (7) observed comparable rates across sexes, reinforcing the observation that KC affects both males and females.
This finding contrasts with earlier reports suggesting male predominance but aligns with more recent evidence indicating that males were more likely than females to receive both collagen crosslinking and keratoplasty treatments, suggesting that gender disparities may be more pronounced in treatment patterns rather than in disease prevalence itself (8).
In this study, the prevalence of keratoconus was higher among Nubian participants (11.9%) compared to non-Nubians (8.6%), although this difference was not statistically significant (p=0.110).
Ethnic background was also significantly associated with more intricate cone location, morphological stage and more irregular topographic patterns, suggesting that ethnicity may influence not only the likelihood of developing KC but also its clinical presentation. These findings support the role of genetic and potentially environmental factors in the expression of the disease, as discussed in recent epidemiological literature (9).
A clear age-related increase in keratoconus prevalence was observed in this current study, from 5.76% in participants ≤19 years to 14.69% in those ≥30 years (p=0.019). This supports the established understanding that keratoconus typically begins in the second decade of life and progresses slowly thereafter (10). Recent trends show earlier diagnosis, with the average age of keratoconus patients decreasing over time from 44.1 years in 2015 to 39.2 years in 2020, likely due to improved detection methods identifying the condition at younger ages (8). This statistically significant trend indicates that age should be considered a crucial factor in keratoconus screening protocols.
A significant association was observed between a positive medical history and increased keratoconus prevalence (33.3% vs. 9.4%, p=0.046), supporting the hypothesis that keratoconus may be linked to broader systemic disorders affecting connective tissue integrity. This finding aligns with previous research demonstrating connections between keratoconus and various systemic conditions, particularly those involving connective tissue abnormalities (11).
This finding underscores the likely genetic component in keratoconus development. Al Qahtani et al. (12) similarly reported that 56.8% of Saudi keratoconus patients had a positive family history.
The frequent occurrence of myopia and astigmatism in eyes affected by keratoconus draw attention to the intrinsic link between corneal irregularity and refractive status. The statistically significant difference in refractive error distribution between ethnic groups in keratoconus cases ($p < 0.001$) suggests a possible ethnic influence on the refractive profile of affected eyes, while no such difference was observed in the non-keratoconus group ($p = 0.097$). This suggests that ethnicity may influence how keratoconus manifests in terms of refractive error, rather than affecting the overall development of refractive errors themselves. This selective ethnic impact on refractive patterns in keratoconus is an intriguing observation that warrants further research to better understand the underlying mechanisms.
Myopia and astigmatism were present in 64.5% of non-Nubian eyes and 35.5% of Nubian eyes. This pattern is consistent with published data,

where myopic astigmatism is the most frequent refractive error in keratoconic eyes, reported in 69.7% to 87.5% of such cases in various populations (13).

This relationship carries significant clinical implications, as highlighted by Ibrahim et al. (14), who investigated the prevalence of keratoconus among Egyptian individuals with high corneal astigmatism. Their findings revealed that subjects with astigmatism of 2 diopters (D) or more had a markedly higher prevalence of keratoconus (12.3%) compared to those with less than 2D of astigmatism (1.7%).

Analysis of astigmatism types in keratoconus revealed that "Against the Rule" (ATR) astigmatism was most prevalent (44.6%), followed by "With the Rule" (WTR) astigmatism (32.3%). This pattern contrasts with the general population, where WTR astigmatism typically predominates, especially among younger individuals. The higher frequency of ATR astigmatism in keratoconus patients likely reflects the inferior-temporal steepening of the cornea, a hallmark of keratoconus morphology as described by Abu-Ameerh et al. (15).

Advanced imaging technologies, such as the Pentacam anterior segment analyzer, have further clarified the relationship between astigmatism patterns and keratoconus, enabling more accurate and earlier detection of the disease. Communally, the predominance of ATR astigmatism and the high prevalence of significant astigmatism in keratoconus patients emphasize the importance of routine corneal topography screening in individuals presenting with moderate to high astigmatism. Early identification is crucial for timely intervention and better visual outcomes.

The literature consistently demonstrates that the presence and pattern of astigmatism are critical for early identification of keratoconus, justifying their use as primary screening criteria particularly in children and adolescents, and in regions with higher disease prevalence. The widespread adoption of corneal tomography has greatly enhanced early detection, enabling timely intervention before significant visual impairment occurs (16).

A comparative analysis of quantitative topographic parameters between ethnic groups revealed no significant differences in basic keratometry values (Kf, Ks, K average) or corneal thickness. However, notable distinctions were observed as Nubian patients exhibited significantly greater corneal decentration (-0.7 ± 0.3 mm) compared to their counterparts (-0.6 ± 0.4 mm, p=0.044). Nubian patients also showed higher posterior corneal elevation (38.5 ± 20.1 μm vs. 35.0 ± 18.3 μm, p=0.035). These findings suggest that while the overall degree of corneal steepening may be similar across ethnic groups, the spatial distribution and posterior corneal involvement can differ.

This is clinically relevant, as posterior elevation has been identified as one of the most effective parameters for distinguishing subclinical keratoconus (17).

The use of the ABCD classification system, combined with detailed topographic analysis, allows for more detection and monitoring of keratoconus. Recognizing subtle ethnic differences in corneal morphology, particularly in parameters like decentration and posterior elevation, may further refine screening protocols and personalized treatment strategies for diverse populations.

The majority of keratoconus cases in this cohort were identified at early stages, with Stages 1 and 2 accounting for over 60% of all cases. This distribution may reflect effective early detection strategies within the population or possibly a natural tendency toward milder disease expression in this group.

Progressive corneal thinning was observed, with mean pachymetry measurements declining from 525.79 μm in Stage 0 to 268.50 μm in Stage 4. This trend confirms the value of corneal thickness as a reliable marker for staging and monitoring keratoconus, consistent with established criteria (17).

Early-stage keratoconus predominates in this population, with corneal thinning serving as a reliable marker for disease progression. Ethnic differences in corneal thickness at advanced stages highlight the potential influence of genetic and biomechanical factors.

The universal presence of astigmatism and its specific patterns reinforces its role as a key screening tool for keratoconus, supporting the use of corneal topography in at-risk individuals for early and accurate diagnosis.

The strong correlations between refractive cylinder and topographic parameters provide valuable insights into the relationship between corneal structure and visual function. The strongest negative correlation with steep K ($\rho = -0.51$, $p < 0.001$) confirms that corneal steepening directly contributes to astigmatic refractive error. These findings highlight the strong structural relationship between corneal shape and refractive cylinder in keratoconic eyes.

These correlations have important implications for patient counseling and treatment planning, particularly given the increasing availability of treatments such as collagen crosslinking, which showed dramatic increases in utilization from 0.05% in 2015 to 29.5% in 2020 (8).
Ultimately, this study demonstrates the highest reported prevalence of keratoconus in Egypt and provides important insights into ethnic variations in disease characteristics. The findings support the need for enhanced screening protocols in this population and contribute to our understanding of keratoconus epidemiology in this region.
The ethnic differences in topographic parameters, particularly posterior elevation and corneal decentration, warrant further investigation to understand their clinical significance and potential impact on treatment outcomes.

Conclusion

In a cohort of 976 participants aged 18–30 years in Aswan Governorate, keratoconus prevalence was 9.5%, with higher rates among Nubians (11.9%) than non-Nubians (8.6%), suggesting potential genetic and regional influences. Astigmatism was the most common refractive error associated with keratoconus, followed by myopia. Both a positive personal medical history and a family history were significantly associated with increased keratoconus risk, highlighting hereditary and systemic factors in disease susceptibility.

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