Original Article

Prevalence of Keratoconus in Patients with Astigmatism more than Two Diopters: A Cross-Sectional Study

Abas Nazar Shakir [1*], Dr. Eman Hussein Alwan [2]

1. M.B.Ch.B, Erbil Teaching Hospital, General Directorate of Erbil Health, Ministry of Health, the Kurdistan Region, Iraq.
2. FICMSCOpht, MB.Ch.B, Department of Surgery / Ophthalmology Unit, College of Medicine, Hawler Medical University.

* Corresponding Author: **Abas Nazar Shakir**, M.B.Ch.B, Erbil Teaching Hospital, General Directorate of Erbil Health, Ministry of Health, the Kurdistan Region, Iraq. Email: abas.alqadhi@gmail.com

Abstract

Background and aim: Keratoconus is defined as a non-inflammatory disorder which is prevalent among younger generations and leads to ocular morbidity and decreased quality of life. The present study was aimed at investigating the prevalence of keratoconus among patients with astigmatism of over 2 diopters and the association between its prevalence and some ocular parameters.

Methods: In a cross-sectional study, 50 patients (100 eyes) with astigmatism >2D who referred to the outpatient clinic of Ophthalmology Department in Hawler and Rizgary Teaching Hospital in Erbil in 2017-2018 were recruited. All of the patients underwent a complete ophthalmic examination including refraction, visual acuity measurement, slit lamp biomicroscopy, and corneal topography with Galilei. The collected data were analyzed through thickness and elevation maps of Galilei and Statistical Package for the Social Sciences version 20.0.

Results: The mean age of the patients was 25.27 years. The mean magnitude of astigmatism was found to be 4.015±1.83051D. Of the 100 studied eyes, 21% were found to have keratoconus. According to the results of corneal biomicroscopy, thinning of stroma was observed in 21 eye, followed by Vogt's striae and Fleischer ring in 8 and 6 eyes, respectively. The most frequent corneal patterns were symmetric bowtie (49%), asymmetric bowtie inferior steeping (15%), and asymmetric bowtie with skewed steepest radial axis (12%). No significant relationship was found between age and keratoconus occurrence. Also, keratoconus development was not significantly associated with right/left eye. However, corneal topography patterns and corneal biomicroscopy findings were significantly correlated with keratoconus occurrence.

Conclusion: Keratoconus is relatively high among patients aged 15-40 years with astigmatism >2D, which can reliably be predicted through thinning of stroma and symmetric bowtie pattern.

Keywords: keratoconus, subclinical keratoconus, astigmatism, corneal topography, corneal tomography,

Introduction

Keratoconus (KCN) is a chronic, non-inflammatory disorder in which the central and paracentral areas of the cornea become thinner as a result of cellular infiltration and neovascularization (1, 2). As one of the most common corneal ectatic disorders, KCN typically afflicts the younger generations and can lead to ocular morbidity which in turn has significant economic and social effects on the patients (3). The development of keratoconus has been attributed to both genetic and environmental risk factors including allergic eye disease, wearing rigid contact lens, rubbing the eyes, oxidative stress, and inflammation (2, 4). Although research has indicated that it is difficult to specify the genetic risk factors for KNC,

there are some risk factors that play a significant role in development and thus prediction of KCN. Some important risk factors included race (5) and positive family history (6). Age has also been considered as a risk factors for KCN, such that the prevalence of keratoconus has been reported to be higher among patients aged10 to 30 years (7).

With regard to the prevalence rate of KCN, different studies have reported different results in different parts of the world. For example, its prevalence has been reported to be 0.0002% in Russia (8), 0.06% in the USA (9), 2.3% in India (10), 2.5% in Iran (11), and 3.9% in Colombia (12). The discrepancy regarding the prevalence of KCN in the literature has been attributed to the difference between the studies in terms of the sample size they examined and the investigative methods they employed (13, 14). The common presentations of KCN are irregular astigmatism and progressive myopia, eventually leading to impairment of vision which is known as unilateral keratoconus (15, 16). Because this condition is asymmetrical in nature, the vision of the fellow eye is usually normal with negligible astigmatism at presentation. It has been reported that half of fellow eyes with normal vision become keratoconus within 16 year, with the greatest risk being observed during the first 6 years of onset (17). According to the research results, it is easy to identify advanced keratoconus because it is characterized by certain topographic and biomicroscopic findings; however, it is quite challenging to diagnose subclinical KCN which is a type of KCN which lacks specific slit-lamp, retinoscopic, or keratometric findings (18, 19). Nowadays, given the novel advances particularly the advent of corneal topography and more recently corneal tomography, there has been a remarkable increase in the capacity of the ophthalmologists to diagnose corneal ectasia (20). Moreover, Galilei dual Scheimpflug system (Ziemer Ophthalmic System AG, Port, Switzerland) which is a noninvasive diagnostic instrument has proved to be an effective in differentiating keratoconus and subclinical keratoconus from normal corneas (21). Given the relatively high prevalence of keratoconus among the teenagers and young adults (22) and its adverse effects on the patients' vision and quality of life (23, 24), the present study was carried out in order to determine the prevalence of keratoconus cases among individuals with two or more diopters (D) of astigmatism and compare Galilei parameters among these patients in order to figure out the association between the patients' demographic and ocular characteristics and prevalence of KCN.

Methods

The present investigation was a cross-sectional study that was carried out in the outpatient clinic of Ophthalmology Department in Hawler and Rizgary Teaching Hospital in Erbil, the Kurdistan Region of Iraq over the period of 2017-2018. For this purpose, 50 patients who were 15-40 years old and had astigmatism >2D and attended the abovementioned clinic were chosen as the study sample. The study sample was selected based on some inclusion and exclusion criteria. The inclusion criteria were the age range of 15-40 years and astigmatism >2D, and the exclusion criteria were age of less than 15 and more than 40 and astigmatism ≤2D. A complete ophthalmic examination

consisting of refraction, visual acuity measurement, slit lamp biomicroscopy, and corneal topography with Galilei was carried out for each patient. In order to diagnose keratoconus and subclinical keratoconus using the ophthalmic examination, the clinical findings and topographic features were collected and confirmed by utilizing the thickness and elevation maps of Galilei.

After the required data were collected from the ophthalmic examinations, an eye was regarded as having keratoconus when there was central or paracentral steepening of the cornea on topography with at least one of the following slit lamp findings: stromal thinning, anterior bulging of cornea, Vogt's striae, Fleischer ring, Descemet's breaks, apical scars, and subepithelial fibrosis. Moreover, subclinical keratoconus was diagnosed when the fellow eye of a patient with keratoconus had one of the following features: normal cornea by slit lamp biomicroscopy, normal keratometry, and ophthalmoscopy but inferior-superior asymmetry or bow-tie pattern with skewed radial axes detected on the tangential maps. Finally, those patients who did not meet these criteria were classified as the normal astigmatic group. The collected data were analyzed using descriptive statics, and the results were expressed as mean and percentage. Moreover, Fisher's Exact Test was run to check the association between the patients' demographic characteristics and the prevalence of KCN. For this purpose, SPSS 20.0 was utilized, and a p-value of $\leq$ 0.05 was considered as statistically significant.

In order to take the ethical consideration into account in the present study, necessary approval was obtained from the Ethical Committee of College of Medicine, Hawler Medical University and an acceptance letter from Erbil Directorate of Health. In addition, verbal consent was obtained from all patients who were also given sufficient explanation about the method, duration, and aim of the study and assured of the confidentiality of their information.

Results

The present study was carried out on 50 patients with astigmatism >2D for the possibility of keratoconus. Analyzing the collected data revealed that the patients mean age was 25.270 with standard deviation of 6.7343, and a range of 15 to 40 years old. The results also indicated that the mean astigmatism was -4.0150D with standard deviation of 1.83051D, a minimum of 2.250D, and a maximum of 9.75D (**Table 1**).

Regarding to other demographic characteristics of the patients of the present study, the results indicated that of the 100 eyes that were examined, 21 had keratoconus (21%), while it was not observed in the rest 79 eyes. Moreover, 27 patients (54 eyes) belonged to the age group 15-24 labeled as youth and 23 (46 eyes) to the age group 25-40 labeled as adults. With regard to the results of corneal biomicroscopy, the results revealed that 65 eyes (65%) were normal and showed no biomicroscopy findings, stromal thinning was observed in 21 eyes (21%), Vogt's striae were seen in 8 eyes (8%), and Fleischer ring was spotted in 6 eyes (6%). In terms of the corneal

topography patterns, the results indicated that the most frequent corneal topography patterns was symmetric bowtie which was observed in 49 eyes (49%), followed by asymmetric bowtie inferior steeping in 15 eyes (15%), asymmetric bowtie with skewed steepest radial axis in 12 eyes (12%), asymmetric bowtie in 8 eyes (8%), asymmetric bowtie superior steeping in 6 eyes (6%), round pattern in 6 eyes (6%), and oval pattern in 4 eyes (4%) (**Table 2**).

In order to examine the association between the patients' demographic and ocular characteristics and development of keratoconus, Fisher's Exact Test was employed. The results indicated that there was no significant relationship between the patients' age and keratoconus development (p=0.1). In addition, no significant association was found between oculus dextrus (OD; right eye) and oculus sinister (OS; left eye) and keratoconus occurrence (p=0.4). However, there was a significant relationship between corneal biomicroscopy and development of keratoconus (p=0.000). Also, the results indicated that the corneal topography patterns and keratoconus development were significantly correlated (p=0.000) (**Table 3**).

Discussion

The present cross-sectional study was carried out in order to investigate the prevalence of keratoconus among 50 patients aged from 15 to 40 years old who were not previously diagnosed with keratoconus. It was also aimed at examining the correlation of the patients' demographic characteristics, corneal biomicroscopy findings, corneal topography patterns, and right/left eye with development of keratoconus.

The results of the present study indicated that the studied patients' mean age was 25.27 years with an age range of 15 to 40. Other similar studies also focused on approximately the same age range. For example, Serdarogullari et al. (2013) studied a group of 65 patients whose mean age was 29.9 years ranging from 15 to 45 (25). Also, Shehadeh et al. (2015) focused on a group of students aged 17 to 27 with a mean age of 21.1 years (26). Hashemi et al. (2014) studied a group of patients aged 20-34 years old (11). The reason for focusing on these age groups in studies of KCN is that research has proved that age is a risk factor for development of this disorder (7) and it usually occurs after adolescence and develops during adulthood (2, 27). Therefore, selection of that age group in the present study was in line with previously conducted investigations.

The results of the present study indicated that the mean astigmatism was 4.0150D with standard deviation of 3.5, a minimum of 2.250, and a maximum of 9.750. Approximately similar to this finding, in their study conducted in Iran, Shajari et al. (2017) concluded that the magnitude of astigmatism in the patients was 3.47±2.10D on the anterior surface and 0.69±0.40 D on the posterior surface in eyes across all keratoconus stages. They also reported a significant correlation between progression of keratoconus and increased anterior and posterior corneal astigmatism (28). Therefore, it can be concluded that magnitude of astigmatism can be a risk factor for development of keratoconus. Similar findings have been

reported by Feizi et al. (2018) who indicated an astigmatism magnitude of 4.01±2.02 for the group with mild-keratoconus, 5.03±2.12 for the moderate keratoconus group, and 6.58±3.43 for the severe keratoconus group (29). By comparing the results of the study conducted by Feizi et al. (2018) and those of the present study, it can be stated that the patients in the present study were in mild risk of developing keratoconus, on average.

As revealed by the results of the present study, out of the 50 right eyes (OD) and 50 left eyes (OS), 21 were diagnosed with keratoconus, while no significant findings were observed for the other 79. This finding revealed that the prevalence rate of keratoconus was higher than those of the previously studies (8-12). The difference between studies regarding their sample size and their investigative methods has been referred to as the reason for this difference (13, 14).

The findings of corneal biomicroscopy indicated that stromal thinning was observed in 21 eyes which were decisively diagnosed as cases of keratoconus. In their study, Reinstein et al. (2010) concluded that normal eyes have stromal thickness progression of 29.9±5.4 µm, while it is 60.6±25.6 µm in eyes with keratoconus (30) which means stroma is thinner in eyes with keratoconus, and it becomes thinner with progression of keratoconus. Zhou and Stojanovic (2014) also referred to thinning of stroma as a significant indication for keratoconus (31).

The results also indicated that Vogt's striae were observed in 8 eyes. Although the eyes with Vogt striae were not diagnosed with keratoconus, they may be at a high risk of developing subclinical keratoconus because, as indicated by Grieve et al. (2017), Vogt striae is one of the known indicators of keratoconus (32). Therefore, more examinations should be carried out for such patients. Also, Shi (2016) also referred to Fleischer ring, which was observed in 6 eyes in the present study, and Vogt's striae as indicators of subclinical keratoconus (33) whose diagnoses requires further examinations.

Based on the thickness and elevation maps of Galilei, the results of the current study also showed that symmetric bowtie (SB) was the most frequently found corneal topography pattern which was observed in 49 patients (49%). In their study conducted in Iran, Hashemi et al. (2014) concluded that SB with 29% was the most frequent pattern (11). Similarly, Munsamy et al. (2015) reported that symmetric bowtie with 36% was the most frequent pattern in patients with keratoconus (34). The second most frequent corneal topography pattern in the present study was found to be asymmetric bowtie inferior steeping (AB/IS) observed in 15 eyes. This finding is in good agreement with those of the study carried out by Hashemi et al. (2014) who reported that AB/IS was seen in 16.7% of the studies eyes (11). The third most frequently observed pattern was asymmetric bowtie with skewed steepest radial axis (AB/SRAX) with 12%, followed by asymmetric bowtie (AB) with 8%, asymmetric bowtie superior steeping (AB/SS) with 6%, round pattern with 6%, and oval pattern with 4%. These findings have been reported by previously conducted studies (35-37).

The results of the present study regarding the association between the studied variable and development of keratoconus indicated that there was not a significant relationship between age and keratoconus occurrence (p=0.1). Although age has been referred to as an important risk factor in keratoconus, the results of the study carried out by Abdu et al. (2016) demonstrated no significant association between age in both genders and keratoconus occurrence (38), which is in good agreement with the present study. The results also indicated that there was no significant relationship between keratoconus development and right/left eye (p=0.4). Similar findings have also been reported by other studies (39, 40).

However, the results indicated that there was a significant association between corneal biomicroscopy findings (including Fleischer rings, stromal thinning, and Vogt's striae) and the development of keratoconus at p=0.000. This finding is in good agreement with the results of the studies carried out by Güngör et al. (2008), Song et al. (2016), and Khaled et al. (2017) (41-43). Therefore, corneal biomicroscopy findings can be utilized as reliable predictors for keratoconus development. The results also revealed that corneal topography patterns are in a significant relationship with keratoconus occurrence (p=0.000). This finding is in line with the results of the studies carried out by Hashemi et al. (2014) and Munsamy et al. (2015) (11, 34). Therefore, it can be stated that corneal topography patterns can reliable predict the development of keratoconus.

One of the limitations of the present study can be mentioned as its small sample size which can limits the generalizability of the results of the present study to other populations. Also, the factors of sex and race were not taken into account during data analysis, which could have affected the results. Therefore, future studies are recommended to recruit larger sample studies and include more demographic characteristics.

Conclusion

According to the results of the present study, keratoconus prevalence was relatively high among the studied patients whose mean age was 25.27 years. The most frequently observed corneal biomicroscopy finding was stromal thinning; therefore, it was figured out as a reliable predictor for keratoconus. Other findings were Fleischer ring and Vogt's striae which can be a possible indication for subclinical keratoconus; therefore, patients with these symptoms needs to undergo further examinations. The results revealed that symmetric bowtie was the most frequent corneal topography pattern, followed by asymmetric bowtie inferior steeping and asymmetric bowtie with skewed steepest radial axis. The results indicated that corneal biomicroscopy findings and corneal topography patterns can had a significant association with keratoconus occurrence; therefore, they can be utilized for reliable diagnosis of this disorder.

References

1. Krachmer JH, Feder RS, Belin MW. Keratoconus and related noninflammatory corneal thinning disorders. Surv Ophthalmol. 1984;28:293–322.

2. Rabinowitz YS. Keratoconus. Surv Ophthalmol. 1998;42:297–319.

3. Gatinel D, Saad A. The challenges of the detection of subclinical keratoconus at its earliest stage. Int J Keratoco Ectatic Corneal Dis. 2012; 1(1): 36-43.

4. Galvis V, Sherwin T, Tello A, Merayo J, Barrera R, Acera A. Keratoconus: an inflammatory disorder?. Eye (Lond). 2015;29(7):843–859. doi:10.1038/eye.2015.63

5. Georgiou T, Funnell CL, Cassels-Brown A, O'Conor R. Influence of ethnic origin on the incidence of keratoconus and associated atopic disease in Asians and white patients. Eye (lond) 2004; 18: 379–383.

6. Bechara SJ, Waring GO, Insler MS. Keratoconus in two pairs of identical twins.Cornea.1996; 15:90–3.

7. Qasim KF and Shahad A. Prevalence of Refractive Errors in Patients with Keratoconus among Sample of Iraqi Population. J Ophthalmol 2017, 2(4): 000134.

8. Gorskova E. N., Sevost'ianov E. N. Epidemiology of keratoconus in the Urals. Vestnik Oftalmologii. 1998;114:38–40. in Russian.

9. Kennedy R. H., Bourne W. M., Dyer J. A. A 48-year clinical and epidemiologic study of keratoconus. American Journal of Ophthalmology. 1986;101:267–273. doi: 10.1016/0002-9394(86)90817-2.

10. Jonas J. B., Nangia V., Matin A., et al. Prevalence and associations of keratoconus in rural Maharashtra in central India: the central India eye and medical study. American Journal of Ophthalmology. 2009;148:760–765. doi: 10.1016/j.ajo.2009.06.024.

11. Hashemi H, Khabazkhoob M, Yazdani N, Ostadimoghaddam H, Norouzirad R, Amanzadeh K et al. The prevalence of keratoconus in a young population in Mashhad, Iran. Ophthalmic Physiol Opt 2014; 34: 519–527.

12. Galvis V, Tello A, Jaramillo JA, Gutierrez AJ, Rodriguez L, Quintero MP. Prevalence of keratoconus patients who consulted with a desire refractive surgery in ophthalmology center reference Bucaramanga, Colombia. Rev Soc Colomb Oftal 2011; 44: 129–134.

13. Dutta N. K., Dutta L. C. Modern Ophthalmology. 3rd. New Delhi, India: Jaypee Brothers; 2005. Applied and functional anatomy of the cornea; p. p. 131.

14. Gordon-Shaag A., Millodot A., Shneor E., Liu Y. The genetic and environmental factors for keratoconus. BioMed Research International. 2015;2015:p. 19. doi: 10.1155/2015/795738.795738

15. M. Millodot, E. Shneor, S. Albou, E. Atlani, and A. Gordon-Shaag, "Prevalence and associated factors of keratoconus in jerusalem: a cross-sectional study," Ophthalmic Epidemiology, vol. 18, no. 2, pp. 91–97, 2011.

16. Vazirani J, Basu S. Keratoconus: current perspectives. Clin Ophthalmol. 2013;7:2019–2030. doi:10.2147/OPTH.S50119

17. Kanski J, Bowling B, Nischal K and Pearson A.Clinical ophthalmology. 7th ed. Edinburgh: Elsevier/Saunders; 2011 p.210-212.

18. McMahon TT, Edrington TB, Szczotka-Flynn L, Olafsson HE, Davis LJ, Schechtman KB. Longitudinal changes in corneal curvature in keratoconus. Cornea. 2006;25:296–305.

19. Li X, Rabinowitz YS, Rasheed K, Yang H. Longitudinal study of the normal eyes in unilateral keratoconus subjects. Ophthalmology 2004;111:440-446

20. Belin MW, Villavicencio OF, Ambrosio R Jr. Tomographic parameters for the detection of keratoconus: suggestions for screening and treatment parameters. Eye Contact Lens. 2014; 40:326–330.

21. Feizi S, Yaseri M, Kheiri B. Predictive Ability of Galilei to Distinguish Subclinical Keratoconus and Keratoconus from Normal Corneas. J Ophthalmic Vis Res. 2016;11(1):8–16. doi:10.4103/2008-322X.180707

22. H. Hashemi, S. Heydarian, A. Yekta et al., "High prevalence and familial aggregation of keratoconus in an Iranian rural population: a population-based study," Ophthalmic and Physiological Optics, vol. 38, pp. 447–455, 2018.

23. Kymes SM, Walline JJ, Zadnik K, Sterling J, Gordon MO. Changes in the quality-of-life of people with keratoconus. Am J Ophthalmol. 2008;145 (4:611–617.

24. Davis LJ, Schechtman KB, Wilson BS, Rosenstiel CE, Riley CH, Libassi DP, et al. Longitudinal changes in visual acuity in keratoconus. Invest Ophthalmol Vis Sci. 2006;47 (2:489–500.

25. Serdarogullari H, Tetikoglu M, Karahan H, Altin F, Elcioglu M. Prevalence of keratoconus and subclinical keratoconus in subjects with astigmatism using pentacam derived parameters. J Ophthalmic Vis Res. 2013;8(3):213–219.

26. Shehadeh MM, Diakonis VF, Jalil SA, Younis R, Qadoumi J, Al-Labadi L. Prevalence of Keratoconus Among a Palestinian Tertiary Student Population. Open Ophthalmol J. 2015;9:172–176. Published 2015 Dec 31. doi:10.2174/1874364101509010172

27. ala El Rami, Elias Chelala, Ali Dirani, et al., "An Update on the Safety and Efficacy of Corneal Collagen Cross-Linking in Pediatric Keratoconus," BioMed Research International, vol. 2015, Article ID 257927, 7 pages, 2015.

28. Shajari M, Friderich S, Pour Sadeghian M, Schmack I, Kohnen T. Characteristics of Corneal Astigmatism of Anterior and Posterior Surface in a Normal Control Group and Patients With Keratoconus. Cornea. 2017;36:457–462.

29. Feizi S, Delfazayebaher S, Javadi MA, Karimian F, Ownagh V, Sadeghpour F. Mean Posterior Corneal Power and Astigmatism in Normal Versus Keratoconic Eyes. J Ophthalmic Vis Res. 2018;13(2):93–100. doi:10.4103/jovr.jovr_19_17

30. Reinstein DZ, Gobbe M, Archer TJ, Silverman RH, Coleman DJ. Epithelial, stromal, and total corneal thickness in keratoconus: three-dimensional display with artemis very-high frequency digital ultrasound. J Refract Surg. 2010;26(4):259–271. doi:10.3928/1081597X-20100218-01

31. Zhou W, Stojanovic A. Comparison of corneal epithelial and stromal thickness distributions between eyes with keratoconus and healthy eyes with corneal astigmatism ≥ 2.0 D. PLoS One. 2014;9(1):e85994. Published 2014 Jan 28. doi:10.1371/journal.pone.0085994

32. Grieve K, Ghoubay D, Georgeon C, Latour G, Nahas A, Plamann K, Crotti C, Bocheux R, Borderie M, Nguyen TM, Andreiuolo F, Schanne-Klein MC, Borderie V. Stromal striae: a new insight into corneal physiology and mechanics. Sci Rep. 2017 Oct 19;7(1):13584.

33. Shi Y. Strategies for improving the early diagnosis of keratoconus. Clin Optom (Auckl). 2016;8:13–21. Published 2016 Feb 24. doi:10.2147/OPTO.S63486

34. Munsamy AJ, Moodley VR, Naidoo P, Mangwarara TR, Abdullah R, Govender D, et al. A frequency analysis of cone characteristics for the different stages of keratoconus. Afr Vision Eye Health. 2015;74(1)

35. Cavas-Martínez F, De la Cruz Sánchez E, Nieto Martínez J, Fernández Cañavate FJ, Fernández-Pacheco DG. Corneal topography in keratoconus: state of the art. Eye Vis

(Lond). 2016;3:5. Published 2016 Feb 22. doi:10.1186/s40662-016-0036-8

36. Matalia H, Swarup R. Imaging modalities in keratoconus. Indian J Ophthalmol. 2013;61(8):394–400. doi:10.4103/0301-4738.116058

37. Patrao LF, Canedo AL, Azevedo JL, Correa R, Ambrosio R, Jr. Differentiation of mild keratoconus from corneal warpage according to topographic inferior steepening based on corneal tomography data. Arq Bras Oftalmol. 2016;79:264-7.

38. M. Abdu, K.H. Binnawi, A.E.M. Elmadina, R. Hassan Clinical profile of keratoconus patients in Sudan Sudan J Ophthalmol, 8 (1) (2016), pp. 20-25

39. Panahi-Bazaz MR, Sharifipour F, Moghaddasi A. Bilateral Keratoconus and Corneal Hydrops Associated with Eye Rubbing in a 7-year-old Girl. J Ophthalmic Vis Res. 2014;9(1):101–105.

40. Dienes L, Kranitz K, Juh asz E, Gyenes A, Tak acs A, Mil altz K, Nagy ZZ, Kovacs I. Evaluation of intereye corneal asymmetry in patients with keratoconus. A Scheimpflug imaging study. PLoS One 2014; 9:e108882.

41. Güngör IU, Beden U, Sönmez B. Bilateral horizontal Vogt's striae in keratoconus. Clin Ophthalmol. 2008;2(3):653–655.

42. Song P, Wang S, Zhang P, et al. The Superficial Stromal Scar Formation Mechanism in Keratoconus: A Study Using Laser Scanning In Vivo Confocal Microscopy. Biomed Res Int. 2016;2016:7092938. doi:10.1155/2016/7092938

43. Khaled ML, Helwa I, Drewry M, Seremwe M, Estes A, Liu Y. Molecular and Histopathological Changes Associated with Keratoconus. Biomed Res Int. 2017;2017:7803029. doi:10.1155/2017/7803029

Tables

Table 1. The patients' age and astigmatism level

Statistics		
	Age	**Astigmatism**
Mean	25.270	4.0150
Median	24.000	3.5000
Std. Deviation	6.7343	1.83051
Minimum	15.0	2.250
Maximum	40.0	9.75

Table 2. The patients' age range and their ocular characteristics

	Frequency (N)	**Percentage (%)**
Keratoconus		
Yes	21	21.0
No	79	79.0
Total	100	100.0
Age		
15 - 24 Youth	54	54.0
25 - 40 Adults	46	46.0
Total	100	100.0
Eye		
Oculus dextrus (OD)	50	50.0
Oculus sinister (OS)	50	50.0
Total	100	100.0
Corneal biomicroscopy		
Fleischer ring	6	6.0
Normal	65	65.0
Stromal thinning	21	21.0
Vogt's striae	8	8.0
Total	100	100.0
Corneal topography patterns		
Asymmetric bowtie	8	8.0
Asymmetric bowtie inferior steeping	15	15.0
Asymmetric bowtie with skewed steepest radial axis	12	12.0
Asymmetric bowtie superior steeping	6	6.0
Oval	4	4.0
Round	6	6.0
Symmetric bowtie	49	49.0
Total	100	100.0

Table 3. The relationship between the studied variables and keratoconus occurrence

	Keratoconus		**Total**	**p-value**
	Yes	**No**		
Age				
15 - 24 Youth	14 (25.9)	40 (74.1)	54 (100.0)	0.1
25 - 40 Adults	7 (15.2)	39 (84.8)	46 (100.0)	
Total	21 (21.0)	79 (79.0)	100 (100.0)	
Corneal biomicroscopy				
Fleischer ring	4 (66.7)	33.3%	6 (100.0)	0.000*
Normal	(00.0)	65(100.0)	65 (100.0)	
Stromal thinning	11(52.4)	10 (47.6)	21 (100.0)	
Vogt's striae	6 (75.0)	2 (25.0)	8 (100.0)	
Total	21 (21.0)	79 (79.0)	100 (100.0)	
Corneal topography patterns				
Asymmetric bowtie	4 (50.0)	4 (50.0)	8 (100.0)	0.000*
Asymmetric bowtie inferior steeping	6 (40.0)	9 (60.0)	15 (100.0)	
Asymmetric bowtie & Symmetric bowtie	1 (50.0)	1 (50.0)	2 (100.0)	
Asymmetric bowtie with skewed steepest radial axis	6 (50.0)	6 (50.0)	12 (100.0)	
Asymmetric bowtie superior steeping	0 (0.0)	6 (100.0)	6 (100.0)	
Oval	4 (100.0)	0 (0.0)	4 (100.0)	
Round	0 (0.0)	6 (100.0)	6 (100.0)	
Symmetric bowtie	0 (0.0)	47 (100.0)	47 (100.0)	
Total	21 (21.0)	79 (79)	100 (100.0)	
Eye				
OD	9 (18.0)	41 (82.0)	50 (100.0)	0.4
OS	12 (24.0)	38 (76.0)	50 (100.0)	
Total	21 (21.0)	79 (79.0)	100 (100.0)	
*Fisher's Exact Test				