ECRONICON OPEN ACCESS

EC OPHTHALMOLOGY
Research Article

Comparative Study on Corneal Profile and Parameters between Generations in Albania

Teuta Haveri[1]*, Nereida Polovina[2], Mimoza Meco[1], Felisia Gjyrdedi[1], Camelia Kojqiqi[1]

[1]*Department of Ophthalmology, American Hospital 1, Tirana, Albania*

[2]*Business School Manchester Metropolitan University, United Kingdom*

***Corresponding Author**: Teuta Haveri, Department of Ophthalmology, American Hospital 1, Tirana, Albania.

Received: January 11, 2020; **Published:** February 29, 2020

Abstract

Background: Keratoconus is a degenerative corneal disease, which has seen an increase in incidence these last years, including pediatric ages. The main focus of this study is trying to understand if these are only sporadic findings, or there is a real change in the corneal profile that could result in future keratoconus in young patients.

Material and Methods: Data was collected from 700 patients, who were examined via three dimensional corneal topography in American Hospital 1. The patients were divided into four groups by age. The studied parameters were: corneal pachymetry in corneal center and thinnest point, keratometry values, maximal value of cornea posterior face, and value of astigmatism.

Results: The Group 4 presented the lowest values of corneal thickness in thinnest point and centre of cornea, a difference that was statistically significant ($p < 0.001$). The values of corneal thickness in the centre of cornea, were higher in the first (pediatric) age group ($p < 0.001$). The pediatric patients recorded lower values of cornea vertical radius K1 and cornea horizontal radius K2, while patients in the second group exhibited the highest values. However, the differences in values between the groups were not statistically significant. The maximal radius of the cornea was higher in patients from the third group, a result that was not statistically significant ($p = 0.17$; $p = 0.65$; $p = 0.52$). Group 1 and Group 4 presented the lowest values of cornea posterior face and were not statistically different ($p = 0.35$).

Higher values of astigmatism were found in the pediatric group, a difference that was statistically significant compared to the other groups ($p = 0.006$; $p = 0.003$; $p \leq 0.001$).

Conclusion: Keratoconus' early signs are high values in corneal radius and posterior face of the cornea, low values of corneal thickness, and high astigmatism. In this study, we found that the first group presented high values of corneal astigmatism, but low values of corneal radius and cornea's posterior face. Also, they presented higher values of corneal thickness. So, there is an increase of corneal astigmatism in pediatric ages, but there were no other predictive signs of keratoconus found in the corneal topography analyses.

Keywords: *Keratoconus; Pediatric; Corneal Topography; Pachymetry; Keratometry; Astigmatism*

Introduction

Keratoconus is an ectatic disease characterized by progressive corneal thinning and protrusion, resulting in a conical shaped cornea, which leads to impairment and gradual deterioration of the visual function, directly impacting the quality of life.

Early descriptions and case reports, date prior to three centuries ago, although all data show a rapid increase in the prevalence and incidence of keratoconus, these last twenty years. This may be partly due to the development of new technologies, which have made possible an early detection in the asymptomatic stage. The reported incidence ranges from 1.3 to 25 per 100,000 per year, and a prevalence of 8.8 - 229 per 100,000 [1,2].

The etiology of keratoconus still brings confusion among physicians and scientists and is not yet fully understood. It is widely considered to be a multifactorial disease, where the environmental factors, such as eye rubbing, atopy [3], sun exposure and climate, work as a trigger in a genetically predisposed patient, precipitating and accelerating the disease process [4].

The genetic basis for the disease may explain the different distribution of incidence, in different countries and regions, being lower in countries like Japan or USA, and higher in Middle East and China [2,5-7] and between ethnic groups [8]. Also, studies have shown that relatives of keratoconus patients have an elevated risk of developing the disease, compared to those with unaffected relatives [9-11]. Recent development in high technology and DNA studies has made possible new researches and approaches in ocular genetics like traditional linkage studies, or candidate genes like homeobox and in trying to identify and replicate the loci where the mutations leading to keratoconus happen [12].

Because of the young age of the patients affected from keratoconus, and the direct damage in their quality of life, it becomes important diagnosing the disease in its early stages, preventing the eventual vision loss and saving the patient from an unavoidable corneal transplant. The most sensitive method of detecting and confirming a diagnosis of keratoconus is corneal topography based on the principles of Placido disc and Scheimpflug imaging. Nowadays topography has become the gold standard method to diagnose and follow the progress of keratoconus [13,14]. Most importantly, it allows the early detection of asymptomatic cases, also called forme fruste or keratoconus suspect. The diagnose and staging are made possible by producing colored topographic maps and disposing various indices for the quantification of the level of irregularity of the corneal morphology, at a local or general level, thus distinguishing keratoconus from normal eyes as well as other conditions, like astigmatism [15]. The early topographic signs are: displacement of the corneal apex [16,17], an area of increased corneal power surrounded by areas of decreasing corneal power, asymmetry in corneal power, corresponding points on topographic maps "red on red", higher corneal radius values, decrease in thinnest-point pachymetry [18], lower values of corneal thickness and high irregular astigmatism.

In our daily practice we come across a considerable number of young patients affected from keratoconus. Corneal topography with Pentacam has become a routine screening and monitoring procedure, that we use in our hospital, in all the young patients and in patients presenting with indications such as high refractive errors. The aim of this study is to compare corneal topography parameters between generations in Albania, while we try to evaluate if there is possible to find any predictive sign of future keratoconus in the parameters of the pediatric age group.

Material and Methods

This study was carried out with the approval of the Department of Ophthalmology, American Hospital Ethics Committee. It was performed by a retrospective review of the data from 700 patients, which were examined for different purposes via three dimensional corneal topography (OCULUS Pentacam® HR) in American Hospital 1, from 2016 to 2019. The examination was performed in both eyes. From the patients, 370 were men and 330 were women. In the study were included patients who presented biomicroscopic signs suggesting of keratoconus (Fleischer ring, Vogt's strie), young patients examined for the first time at our hospital, and patients presenting high refractive errors, high values of astigmatism or unability to correct with glasses. Patients with inflammatory disease of the eyes, corneal trauma, corneal opacifications and scarring, and patients who had undergone corneal surgery, including surgery for keratoconus, were excluded from the study. Prior to corneal topography, the patients had a full ocular examination with the autorefractor and Snellen chart to determine the refractive error, uncorrected visual acuity and best corrected visual acuity, and the slit lamp biomicroscope.

The patients were divided into four groups by age: Group 1 included 216 patients aged up to 14 years old, Group 2 included 125 patients with ages varying from 15 to 20 years old, Group 3 was made up by 274 patients aged 21 to 40 years old, and Group 4 contained 85 patients aged 41 years old and above. The parameters that we analyzed were corneal pachymetry in corneal center and thinnest point, main keratometry values: vertical radius (K1), horizontal radius (K2) and maximal keratometry (Kmax), maximal value of cornea posterior face, and the value of astigmatism. Thus, it was possible to obtain patterns for the following analyses and provide an overview of the

patients corneal measurements as per their age groups. For the diagnoses of keratoconus, the Amsler-Krumeich classification was used [19]. According to this classification, stage 1 is defined as eccentric steepening, myopia and/or astigmatism < 5 D, and/or central keratometry value < 48 diopter (D); stage 2 involves myopia and/or astigmatism of 5-8 D, central keratometry value < 53 D, and minimum corneal thickness > 400 µm; stage 3 is defined as myopia and/or astigmatism of 8 - 10 D, central keratometry value > 53 D and minimum corneal thickness 300 - 400 µm; and in stage 4, refraction is not measurable, central keratometry value is > 55 D, there is central corneal scarring and minimum corneal thickness is < 200 microns. Data was analysed with SPSS statistical program (Statistical Package for the Social Sciences, SPSS Inc., Chicago, Illinois) to obtain descriptive statistics, with the results summarized as frequencies for categorical variables and mean and standard deviation for continuous variables. A Pearson bivariate analysis was undertaken to highlight the correlation between the variables of interest. A *p* value of 0.05 and less was taken in consideration as statistically significant.

Limitations of this study include its retrospective nature and the limited number of subjects.

Results

In our study, the patients were divided into four groups by age (Figure 1): Group 1 included 216 patients aged up to 14 years old; Group 2 included 125 patients aged from 15 to 20 years old; Group 3 was consisted of 274 patients aged 21 to 40 years old; and Group 4 contained 85 patients aged 41 years old and above.

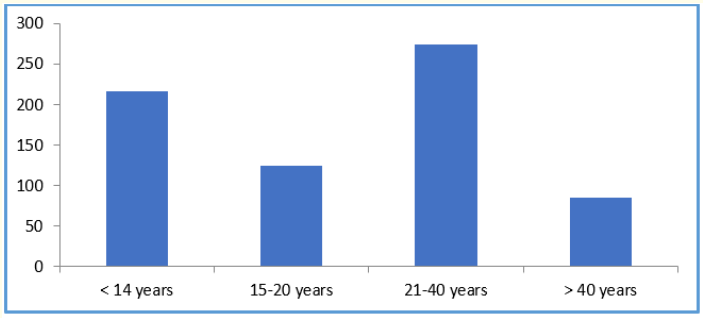

Figure 1: Number of patients as per their age group.

From the present sample (n = 700), 83 patient exhibited keratoconus (Table 1). Most of the patients with the disease were aged between 21 to 40 years old (third age group with 59.03%), while the other age groups, the under 14 years old and over 40 years old had an identical number of patients suffering from keratoconus (16.86%). The second age group (15-20 years old) had the lowest number of patients diagnosed with keratoconus (7.22%).

Stages	Under 14 years		15 - 20 years		21 - 40 years		Over 40 years		Total (n = 83)	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
1	2	2.40%	1	1.20%	3	3.61%	0	0%	6	7.22%
2	4	4.81%	2	2.40%	25	30.12%	6	7.22%	37	44.57%
3	5	6.02%	3	3.61%	20	24.09%	6	7.22%	34	40.96%
4	3	3.61%	0	0 %	1	1.20%	2	2.40%	6	7.22%
Total	14	16.86%	6	7.22%	49	59.03%	14	16.86%	83	100%

Table 1: *Keratoconus stages by age groups (categorical variable).*

Moreover, the majority of the patients with the disease were in stage 2 and stage 3, at the time of the diagnosis, with 44.57% and 40.96% respectively. The incipient and the last phase of keratoconus were present in the same amount of patients (7.22%). As stated above, for the staging of keratoconus was used the Amsler-Krumeich staging system.

As for the laterality of the disease, in Group 1, 3 patients had the disease only in one eye, and 11 in both eyes; in Group 2, the disease presented unilaterally in only 2 patients, and bilaterally in 4 patients; in Group 3, 13 patients had the disease in one eye, and 36 in both eyes; and in Group 4, the disease was unilateral in 4 patients and bilateral in 10 patients. The majority of the patients presenting the disease unilaterally, were in stage one. This data is presented in figure 2.

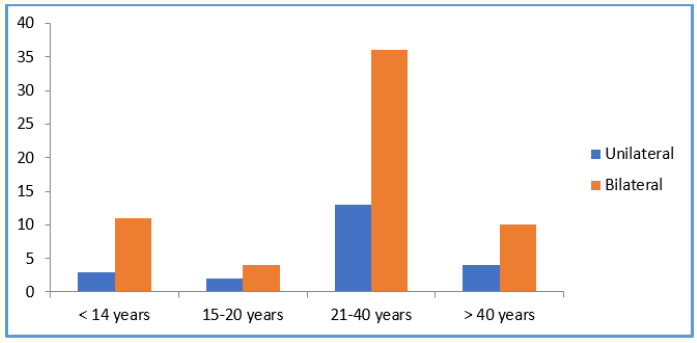

Figure 2: Laterality of keratoconus in affected patients.

Regarding the measurements of corneal thickness in thinnest point, it is seen that the third age group (20-40 years old) exhibited lower values (516.12 ± 55.58 um) than the first age group (545 ± 45.57 um) and the second age group (541.90 ± 35.41 um). The fourth age group had the highest values of corneal thickness (549.42 ± 43.89 um). The difference was statistically significant between the first and the third age group ($p \leq 0.001$), between the first and fourth age group ($p = 0.03$), and between the second and third age group ($p \leq 0.001$). However, the difference between the first and second group was not statistically significant ($p = 0.94$). Similarly, the difference was not statistically significant between the second and fourth age group ($p = 0.17$) (Figure 3).

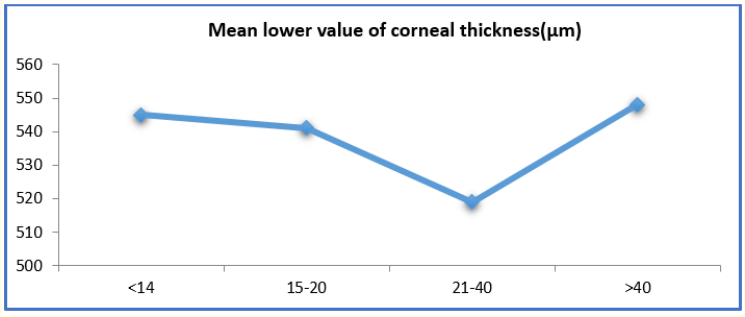

Figure 3: Mean value of corneal thickness in thinnest point.

The measurements of the central corneal thickness showed higher values in the first age group (549.42 ± 43.89 um) than the second age group (546.12 ± 35.78 um), a difference that was not statistically significant (p = 0.94). Likewise, the measurements were greater in the first age group than the fourth age group (533.87 ± 69.49 um); this difference was statistically significant ($p \leq 0.001$). The third age

group exhibited lower measurements of the central corneal thickness (519.58 ± 60.34 um) than the first and second age groups, differences that were statistically significant ($p \leq 0.001$). Correspondingly the measurements for the third age group were lesser than the fourth age group, however the difference was not statistically significant ($p = 0.13$) (Figure 4).

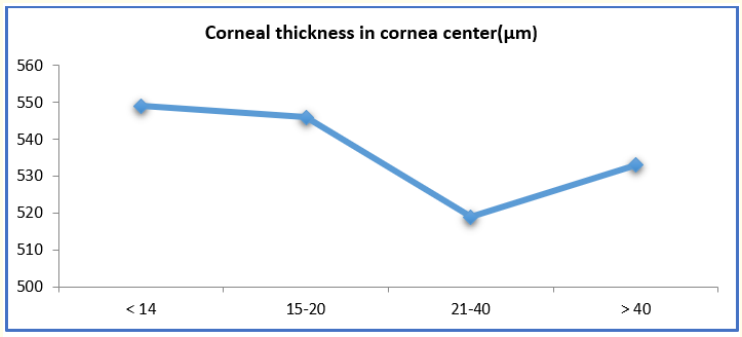

Figure 4: Mean value of corneal thickness in the center of cornea.

The patients younger than 14 year old (Group 1) presented the lowest values of cornea's vertical radius K1 (49.64 ± 51.45 D), followed by the patients in the fourth age group (51.75 ± 51.19 D), and then the third age group (52.25 ± 59.64 D). Patients in the second age group showed the highest values of K1 (66.59 ± 92.80 D). These differences were not statistically significant, with $p = 0.99$; $p = 0.08$ and $p = 96$, respectively. The differences in measurements between the second age and the third age group were not statistically significant ($p = 0.16$). Correspondingly, there was not a statistically significant difference between the measurements of cornea first radius for the second age group and fourth age group ($p = 0.35$) (Figure 5).

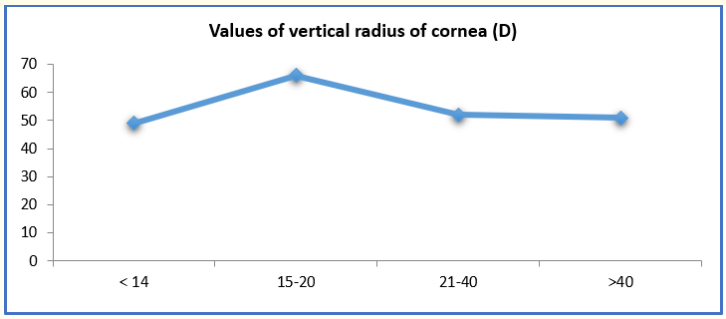

Figure 5: Mean values of vertical radius of cornea (K1).

The patients in the first age group, also presented lower values of the horizontal radius of cornea K2 (45.04 ± 3.49 D), than the patients in the fourth age group (49.07 ± 42.06 D), in the second age group (47.48 ± 35.01 D) and the third age group, who showed the highest values of K2 (51.50 ± 55.04.D). However, this differences between the groups are not statistically significant ($p = 0.86$; $p = 0.29$; $p = 0.95$). Furthermore, the second age group recorded just slightly higher values than the third and fourth group, difference that is not statistically significant ($p = 0.79$, $p = 0.99$) (Figure 6).

The maximal radius of the cornea was higher in patients from the third age group (53.04 ± 54.75 D) compared with the other three age groups, that had similar measurements (46.03 ± 4.69 D; 48.32 ± 36.54 D; 46.65 ± 5.20 D); however they were not statistically significant ($p = 0.17$; $p = 0.65$; $p = 0.52$) (Figure 7).

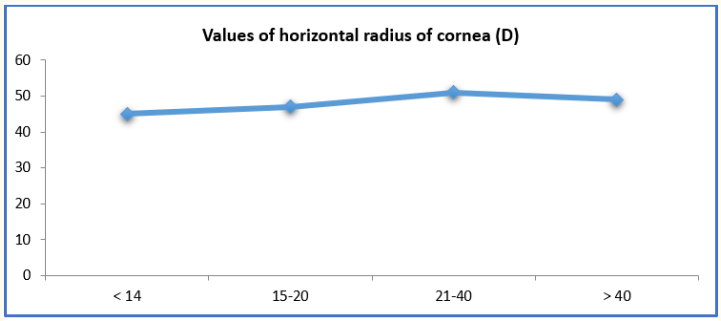

Figure 6: Mean values of horizontal radius of cornea (K2).

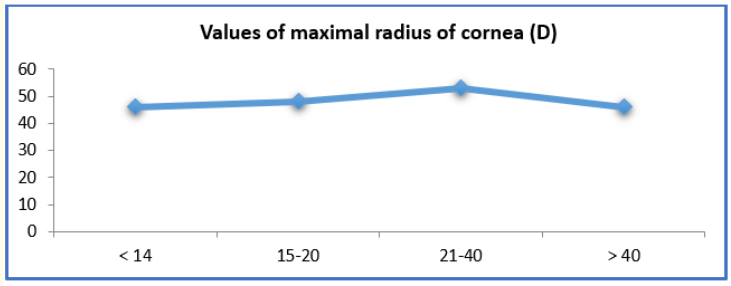

Figure 7: Mean values of maximal radius of cornea (Kmax).

We also measured the values of the corneal astigmatisms; it was shown to be higher in the patients under 14 years old (2.60 ± 4.54 D) compared with the second age group (0.99 ± 1.07 D), the third age group (0.93 ± 2.86 D) and the fourth age group (0.47 ± 3.38 D), differences that were statistically significant ($p = 0.006$; $p = 0.003$; $p \leq 0.001$). On the other hand the difference between the second and the third age group was not statistically significant ($p = 0.99$). Similarly, the difference between the second and the forth age group was not statistically significant ($p = 0.97$) (Figure 8).

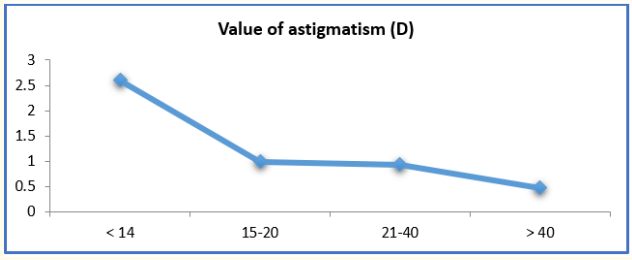

Figure 8: Mean values of astigmatism

Lastly, the maximal value of cornea's posterior face was lower in the young patients (under 14 years old) (59.10 ± 179.92 um), than the patients above 40 years old (99.34 ± 211.61 um), difference that was not statistically significant ($p = 0.35$). Similarly, the patients in the first age group were recording lower values than the patients comprised in the second age group (156.15 ± 246.82 um) and third age group (201.07 ± 256.00 um), differences that were statistically significant ($p \leq 0.001$; $p \leq 0.001$). The differences in maximal value of

cornea's posterior face between the second and third age group were not statistically significant ($p = 0.30$) as well. Correspondingly, the differences in measurements between the second and fourth groups were not statistically significant ($p = 0.230$) while the differences between the third and fourth age groups were statistically significant ($p \leq 0.001$) (Figure 9).

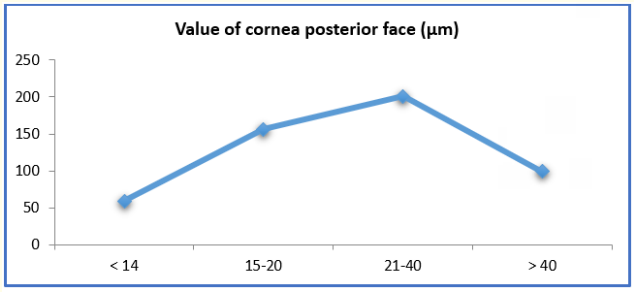

Figure 9: Mean values of cornea posterior face.

In table 2 below, are shown the values and measurements for each parameter discussed above, divided accordingly to the age groups.

A Pearson product momentum was computed to assess the relationship between the values of corneal thickness in thinnest and the first radius of cornea in dioptre. The results highlighted that there is a statistically significant relationship, r = -0.079, p = 0.037. The direction of the relationship is negative, so overall there was a negative correlation between values of corneal thickness and the first radius of the cornea. The lower the measurements of corneal thickness are, the higher are the values of the first radius of the cornea.

Similarly, there is statistically significant relationship between the values of corneal thickness in thinnest point and the second radius of cornea, $r = -0.132$, $p \leq 0.001$. The direction of the relationship is negative, so there was a negative correlation between lower values of corneal thickness and the second radius of the cornea. Hence a decrease in the measurements of corneal thickness corresponds to an increase in the values of the second radius of the cornea.

The values of corneal thickness in thinnest point and the maximal radius of cornea have a statistically significant relationship $r = -0.152$, $p \leq 0.001$. There is a negative correlation between the lower values of corneal thickness and the maximal radius of the cornea. Lower values of corneal thickness are correlated with an increase in the maximal radius of cornea.

The corneal thickness in the centre of cornea and measurements of the first radius of the cornea have a negative relationship, $r = -0.079$, $p = 0.037$. There is a strong negative correlation between the two variables. A decrease in corneal thickness in the centre of cornea is correlated with an increase in the values of the first radius of cornea.

The corneal thickness in the centre of cornea and the measurements of the second radius of the cornea have a negative relationship, $r = -0.113$, $p = 0.003$. Subsequently there was a negative correlation between values of corneal thickness in the centre and the second radius of the cornea. A reduction in corneal thickness in the centre of cornea is associated with a rise in the values of the first radius of cornea.

The corneal thickness in the centre of cornea and the maximal radius of the cornea have a statistically significant relationship $r = -0.130$, $p = 0.001$. The direction of the relationship is negative, so there was a negative correlation between values of corneal thickness in the centre and the maximal radius of the cornea. Thus, the lower the corneal thickness in the centre of the cornea, the higher are the measurements of the maximal radius of cornea.

Variables	Obs.	Mean	Std. Dev.	Min.	Max.
Up to 14 years old					
Lower value of corneal thickness	216	545.05	45.57	351	643
Corneal thickness in the centre of cornea	216	549.42	43.89	372	628
First radius of cornea	216	49.64	51.45	37.60	440
Second radius of cornea	216	45.04	3.49	40	68
Maximal radius of cornea	216	46.03	4.69	41	73
Value of corneal astigmatisms	216	2.60	4.54	1	45.6
Max. value of cornea posterior face	216	59.10	179.92	-19	637
15 to 20 years old					
Lower value of corneal thickness	125	541.90	35.41	391	624
Corneal thickness in the centre of cornea	125	546.12	35.78	394	656
First radius of cornea	125	66.59	92.80	35.40	444.60
Second radius of cornea	125	47.48	35.01	39	435
Maximal radius of cornea	125	48.32	36.54	4	450
Value of corneal astigmatisms	125	.996	1.07	.0	6.4
Max. value of cornea posterior face	125	156.15	246.82	-24	741
20 to 40 years old					
Lower value of corneal thickness	274	516.12	55.58	42	628
Corneal thickness in the centre of cornea	274	519.58	60.34	43	632
First radius of cornea	274	52.25	59.64	38.80	502
Second radius of cornea	274	51.50	55.04	40	541
Maximal radius of cornea	274	53.04	54.75	40	571
Value of corneal astigmatisms	274	.936	2.86	.0	44.7
Max. value of cornea posterior face	274	201.07	256.00	-58	648
41 years old +					
Lower value of corneal thickness	85	549.42	43.89	372	678
Corneal thickness in the centre of cornea	85	533.87	69.49	339	852
First radius of cornea	85	51.75	51.19	36	396
Second radius of cornea	85	49.07	42.06	4	428
Maximal radius of cornea	85	46.65	5.20	41	73
Value of corneal astigmatisms	85	0.47	3.38	0	30
Max. value of cornea posterior face	85	99.34	211.61	-122	675

Table 2: *Sample characteristics (Continuous variables) by age groups.*

Values given as n and mean ± SD (standard deviation).

Variable 1	Variable 2	N	Pearson correlational coefficient	Sig.
Lower value of corneal thickness	First radius of cornea	700	- .079	.037
	Second radius of cornea	697	- . 132	.000
	Maximal Radius of cornea	699	- .152	.000
Corneal thickness in the centre	First radius of cornea	700	- .079	.037
	Second radius of cornea	697	- .113	.003
	Maximal Radius of cornea	699	- .130	.001

Table 3: *Correlation results of corneal measurements.*

Discussion

Keratoconus is a complex and multifactorial eye disease. Because of its severity and the difficulty in treating advanced and complicated forms, early diagnosis becomes essential in preventing the damage it can cause to the quality of life [20].

Corneal topography has become the golden standard for the diagnosis of keratoconus, as it is a non invasive technique which offers morphological characterization of the cornea and extracts qualitative and quantitative indices, that permit a reliable diagnosis. Topographic early signs of keratoconus are displacement of the corneal apex [16,17], generally eccentric with an inferior-temporal spatial orientation, low values of corneal thickness, high values in corneal radius and cornea posterior face, accompanied also by high values of astigmatism.

In this study, we attempted to identify and compare some of the main indices of corneal topography between generations, and analyse the correlation between the variables of interest. Our purpose was to see if we could find changes in the pachymetry and keratometry values in the pediatric ages, prior to the establishment of the disease that could predict a future keratoconus.

In our study, 83 subjects out of 700 exhibited keratoconus. From this sample, the higher number of cases with keratoconus were in Group 3 aged between 21 to 40 years old (59.03%). It was followed by Group 1 (the under 14 years old) and Group 4 (over 40 years old), which had an identical number of patients suffering from keratoconus (16.86%). The second age group (14 to 20 years old) had the lowest number of patients diagnosed with the disease (7.22%).

Generally, the onset of the disease usually occurs in the second decade of life, although some cases may develop in early adulthood [13] and it seldom appears after the age of 35 years [20]. It is a progressive condition which usually stabilizes by the fourth decade of life [20-22]. The average age is as follows as reported in different literatures: Pouliquen 1981: 20.4 years old [23], Kennedy 1986: 29 years old [2], Tuft 1992: 25 years old [24], Zadnik 1998: 28 years old [11] and Owen 2003: 22.9 years old [25].

The patients from Group 3, who made up the largest percentage of patients with keratoconus, were shown to have the lowest values of corneal thickness in thinnest point and central thickness, while they exhibited statistically significant high levels of corneal radiuses K1, K2 and Kmax. Also, the maximal value of cornea's posterior face, was the highest in Group 3 patients, a difference statistically significant compared to the other three groups.

The pediatric patients of Group 1 showed the highest level of astigmatism, a difference that was statistically significant compared to the other groups ($p = 0.006$; $p = 0.003$; $p \leq 0.001$). They presented high values of corneal thickness in thinnest point and the highest values of central thickness. On the other hand, they showed the lowest values of the corneal radiuses and of cornea's posterior face. The pediatric patients did not show alteration in the values of the topography, which could predict changes leading to keratoconus. It was noted that the most common finding was the high prevalence of astigmatism. A high prevalence of astigmatism in pediatric ages was demonstrated by D Fan., *et al.* where 53% of children who participated in the study (the mean age was 55.7 months), had astigmatism [26].

The Pearson bivariate analyses of our data showed a negative correlation between the values of pachymetry, and the radiuses of the cornea. This finding was supported by other studies. Longanesi and Cavallini [27], found a highly significant statistical correlation between the corneal thickness and the radius of curvature of the anterior surface of the cornea along the principal corneal meridians (horizontal and vertical meridians). Similar results were achieved by Shimmio., *et al* [28].

Our study also shows that most of the patients were diagnosed in the second and third stage of the disease, while only 7.22% (6 patients) were diagnosed in the last stage. This once again enhances the importance and efficiency of corneal topography in an early diagnosis in stages where a cross linking procedure can be applied, with excellent results. Stage 4 patients presented in our hospital were treated with the DALK procedure. The pediatric patients in Group 1 presented the most cases with stage 4 keratoconus. A study conducted by Saini [29] reported that eyes with severe keratoconus present at a younger average age (18.8 +/- 5.35 years) more than moderate keratoconus, and also patients who exhibit keratokonus at a younger age, have a faster progression than those who exhibit it in the late teens.

Conclusion

Pediatric patients are shown to exhibit high levels of astigmatism, which seems to be the most common vision problem in this age group. Despite the fact that 16.68% of our patients with keratoconus are under 14 years old, these findings seem to be sporadic, as there are not found any predictive indices for a possible future keratoconus in the other patients of the pediatric group.

Acknowledgements

None.

Conflict of Interest

No conflict of interest.

Financial Disclosure

The authors alone are responsible for the content and writing of the paper. The authors declared that this study received no financial support.

Bibliography

1. McGhee CN. "2008 Sir Norman McAlister Gregg Lecture: 150 years of practical observations on the conical cornea - what have we learned?" *Clinical and Experimental Ophthalmology* 37.2 (2009): 160-176.

2. Kennedy RH., *et al*. "A 48-year clinical and epidemiologic study of keratoconus". *American Journal of Ophthalmology* 101.3 (1986): 267-273.

3. AM Bawazeer., *et al*. "Atopy and keratoconus: a multivariate analysis". *British Journal of Ophthalmology* 84.8 (2000): 834-836.

4. J Sugar and MS Macsai. "What causes keratoconus?" *Cornea* 31.6 (2012): 716-719.

5. Tanabe U., *et al*. "Prevalence of keratoconus patients in Japan". *Nihon Ganka Gakkai Zasshi* 89 (1985): 407-411.

6. Assiri AA., *et al*. "Incidence and severity of keratoconus in Asir province, Saudi Arabia". *British Journal of Ophthalmology* 89.11 (2005): 1403-1406.

7. JB Jonas., *et al*. "Prevalence and associations of keratoconus in rural Maharashtra in central India: the Central India Eye and Medical Study". *The American Journal of Ophthalmology* 148.5 (2009): 760-765.

8. AR Pearson, *et al*. "Does ethnic origin influence the incidence or severity of keratoconus?" *Eye* 14.4 (2000): 625-628.

9. CA Jordan., *et al*. "Computerized corneal tomography and associated features in a large New Zealand keratoconic population". *Journal of Cataract and Refractive Surgery* 37.8 (2011): 1493-1501.

10. L Szczotka-Flynn., *et al*. "Disease severity and family history in keratoconus". *British Journal of Ophthalmology* 92.8 (2008): 1108-1111.

11. Zadnik K., *et al*. "Baseline findings in the Collaborative Longitudinal Evaluation of Keratoconus (CLEK) study". *Investigative Ophthalmology and Visual Science* 39 (1998): 2537-2546.

12. A Gordon-Shaag., *et al*. "The Genetic and Environmental Factors for Keratoconus". *BioMed Research International* (2015): 795738.

13. YS Rabinowitz. "Keratoconus". *Survey of Ophthalmology* 42.4 (1998): 297-319.

14. N Maeda., *et al*. "Automated keratoconus screening with corneal topography analysis". *Investigative Ophthalmology and Visual Science* 35.6 (1994): 2749-2757.

15. F Cavas-Martínez., *et al*. "Corneal topography in keratoconus: state of the art". *Eye and Vision* 3 (2016): 5.

16. Gomes JA., *et al*. "Global consensus on keratoconus and ectatic diseases". *Cornea* 34.4 (2015): 359-369.

17. McGhee CN., *et al*. "Contemporary Treatment Paradigms in Keratoconus". *Cornea* 34.10 (2015): S16-S23.

18. Sahin A., *et al*. "Two-year interval changes in Orbscan II topography in eyes with keratoconus". *Journal of Cataract and Refractive Surgery* 34.8 (2008): 1295-1299.

19. Değirmenci C., *et al*. "Topographic Evaluation of Unilateral Keratoconus Patients". *Turkish Journal of Ophthalmology* 49.3 (2019): 117-122.

20. JH Krachmer., *et al*. "Keratoconus and related noninflammatory corneal thinning disorders". *Survey of Ophthalmology* 28.4 (1984): 293-322.

21. A Ertan and O Muftuoglu. "Keratoconus clinical findings according to different age and gender groups". *Cornea* 27.10 (2008): 1109-1113.

22. SJ Tuft., *et al*. "Prognostic factors for the progression of keratoconus". *Ophthalmology* 101.3 (1994): 439-447.

23. Poupliquen Y., *et al*. "Evaluation of the rapidity of progression of keratoconus by a study of the relationship between age when first detected and age at operation (authors transl)". *Journal Français D'Ophtalmologie* 4 (1981): 219-221.

24. Tuft SJ., *et al*. "Myopia following penetrating keratoplasty for keratoconus". *British Journal of Ophthalmology* 76.11 (1992): 642-645.

25. Owens H and Gamble G. "A profile of keratoconus in New Zealand". *Cornea* 22.2 (2003): 122-125.

26. DSP Fan., *et al*. "Astigmatism in Chinese preschool children: prevalence, change, and effect on refractive development". *BMJ* 88.7 (2003): 938.

27. Cavallini L., *et al*. "Quantitative clinical anatomy of the human cornea in vivo". *Acta Anatomica* 157.1 (1996): 73-79.

28. Shimmyo M., *et al*. "Intraocular pressure, Goldmann applanation tension, cornea thickness, and corneal curvature in Caucasians, Asians, Hispanics, and African Americans". *American Journal of Ophthalmology* 136.4 (2003): 603-611.

29. Saini JS., *et al*. "Keratoconus in Asian eyes at a tertiary eye care facility". *Clinical and Experimental Optometry* 87.2 (2004): 97-101.

Volume 11 Issue 3 March 2020