Keratoconus in pediatric age: Clinical-refractive characteristics and evolution. Donum foundation medical specialties center. Cuenca. Ecuador. 2015-2018

Queratocono en edad pediátrica: características clínico-refractivas y evolución. Medical specialties center fundación donum, Cuenca, Ecuador, 2015-2018

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Abstract

Objective: The objective of the study was to describe the clinical-refractive characteristics of keratoconus (KC) patients at pediatric age and their evolution, at the Donum Foundation Medical Center, Cuenca, Ecuador. **Methods:** An observational, prospective, and longitudinal study was carried out in 94 pediatric patients (188 eyes) diagnosed with KC, diagnosed in 2015 and followed up to 2018, in the Donum Foundation Medical Center, Cuenca, Ecuador. The arithmetic mean of the sample was obtained: mean keratometry, pachymetry at the thinnest point and refractive cylinder, at two moments. The analysis of variance of repeated measures was used for a factor with confidence interval adjustment by Bonferroni and p-value. **Results:** A statistically significant increase was obtained between the mean value of average keratometry of the sample (49.6 D), at the time of diagnosis, and the mean value of average keratometry at 3 years of follow-up (52.4 D). ($p = 0.02$; $\alpha = 0.05$) A statistically significant decrease was obtained between the average pachymetry of the sample, at the time of diagnosis (482 μm), and the average pachymetry of the sample, at 3 years of follow-up (459 μm) ($p = 0.03$; $\alpha = 0.05$). A statistically significant increase was obtained between the average refractive cylinder of the sample, at the time of diagnosis (4.6 D), and the average refractive cylinder of the sample, at 3 years of follow-up (5.1 D) ($p = 0.01$; $\alpha = 0.05$). **Conclusions:** The modifications of keratometry, refractive cylinder, and pachymetry suggest progression of the disease in this age group, in a period of 3 years.

Key words: Keratoconus. Keratometry. Pachymetry. Refractive cylinder. Visual acuity.

Resumen

Objetivo: Describir las características clínico-refractivas de pacientes con queratocono (KC) en edad pediátrica y su evolución, en el Centro de Especialidades Médicas Fundación Donum, Cuenca, Ecuador. **Método:** Se realizó un estudio observacional, prospectivo y longitudinal en 94 pacientes en edad pediátrica (188 ojos) con diagnóstico de KC, diagnosticados en 2015 y seguidos hasta 2018, en el Centro de Especialidades Médicas Fundación Donum, Cuenca, Ecuador. Se obtuvo la media aritmética de la muestra de: queratometría media, paquimetría en el punto más delgado y cilindro refractivo, en dos momentos. Se empleó el análisis de varianza (ANOVA) de medidas repetidas para un factor con ajuste del intervalo de

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confianza por Bonferroni y valor p . **Resultados:** Se obtuvo un aumento estadísticamente significativo entre el valor promedio de queratometría media de la muestra en el momento del diagnóstico (49.6 D) y el valor promedio de queratometría media a los 3 años de seguimiento (52.4 D) ($p = 0.02$; $\alpha = 0.05$); una disminución estadísticamente significativa entre la paquimetría promedio de la muestra en el momento del diagnóstico (482 μm) y la paquimetría promedio de la muestra a los 3 años de seguimiento (459 μm) ($p = 0.03$; $\alpha = 0.05$); y un incremento estadísticamente significativo entre el cilindro refractivo promedio de la muestra en el momento del diagnóstico (4.6 D) y el cilindro refractivo promedio de la muestra a los 3 años de seguimiento (5.1 D) ($p = 0.01$; $\alpha = 0.05$). **Conclusiones:** Las modificaciones de queratometría, cilindro refractivo y paquimetría sugieren progresión de la enfermedad en este grupo de edad, en un periodo de 3 años.

Palabras claves: Queratocono. Queratometría. Paquimetría. Cilindro refractivo. Agudeza visual.

Introduction

In our daily ophthalmology practice, we find different cases that, occasionally, take all our attention for their clinical relevance and interesting evolution. Ectasia, specifically keratoconus (KC), with a pediatric presentation, is a clinical-surgical challenge. Regardless of the technological advances that have occurred in recent decades, the management of a pediatric patient with KC can lead to a long follow-up full of doubts, contradictions, and surgical decisions made at the wrong time, among other issues that deserve all our attention.

Pediatric KC entails several distinctive management problems compared to adult KC, regarding the difficulty for diagnosis by corneal topography (cooperation and accessibility) and modifications in treatment schemes. The main concerns include the accelerated progression of the disease in the pediatric age group and the management of comorbidities such as vernal keratoconjunctivitis¹.

KC is an inflammatory or quasi-inflammatory disease, in which the cornea adopts a conical shape due to thinning and protrusion². It occurs at puberty and progresses until the third or fourth decades of life. The incidence is of 1/2000 cases in the population^{1,3}. Clinically, this ectasia leads to myopia and irregular astigmatism¹⁻⁴. The etiology is not yet well clarified. It commonly arises from the combination of genetic and environmental factors²⁻⁴.

The biomechanical resistance of the cornea depends on the covalent bonds between the collagen molecules. In KC, activated keratocytes invade the previously altered Bowman membrane, with subsequent apoptosis, loss of the anterior stroma, and progressive corneal thinning. In KC, stromal resistance decreases by 50%³⁻⁵.

The timing of diagnosis continues to be the main factor for evolution prediction. Cases may be diagnosed in different stages, from a still subclinical KC to cicatricial corneal leukomas secondary to acute hydrops that

went unnoticed. There are also cases of different stages of the disease observed in the same patient, which highlights its asymmetric behavior.

There are different studies in the world and Latin America, on the clinical and refractive characteristics of this disease. The most current studies focus on the effectiveness of crosslinking as an alternative treatment in pediatric patients with the disease⁶⁻⁸.

In Ecuador, April⁹ performed corneal topography on 32 patients with this disease in Quito and Santo Domingo, obtaining pachymetry and keratometry values. Mansfield¹⁰ reported a frequency of KC of 0.75% in a group of patients in the city of Quito who underwent corneal topography. In Cuenca, Reynoso¹¹ showed a disease frequency of 28.6% in patients who underwent corneal topography.

However, the studies are not aimed at specific age groups. Investigations of KC in pediatric age would make possible its early diagnosis, as well as greater effectiveness and optimization of treatments, with the aim of improving or at least maintaining, the visual acuity of the patients, and reducing the possibility of a corneal transplant.

Objectives

General

The objective of the study was to describe the clinical and refractive features of pediatric patients with KC and their evolution in the Fundación Donum, Cuenca, Ecuador.

Specific

The following specific is as follows:

- To characterize the study sample according to its sociodemographic characteristics.
- To distribute the sample according to associated systemic diseases, signs, and symptoms.

- To classify patients according to refractive errors, topographic patterns, and KC type.
- To determine the possible modifications of keratometry, pachymetry, and refractive cylinder between diagnosis and 3 years after diagnosis.

Methods

This was an observational, prospective, and longitudinal study in 94 pediatric patients (188 eyes) with a KC diagnosis in 2015 and followed up until 2018, in the Medical Specialties Center Fundación Donum, Cuenca, Ecuador.

Criteria for the selection of cases

INCLUSION CRITERIA

The following criteria were included in the study:

- Age <18 years old
- Diagnosis of KC (the presence of topographic/topographic criteria for the disease by Pentacam and the presence of clinical alterations in the examination were considered for diagnosis: irregularity of light reflection in the cornea, Munson's and Rizzuti's signs, presence of Fleischer's ring, Vogt's striae).

EXCLUSION CRITERIA

The following criteria were excluded from the study:

- Patients who did not attend visits during the 3 years.
- Guardians who did not grant informed consent for participation in the study.

Study variables

- Signs.
- Refractive errors.
- Refractive cylinder.
- Topographic pattern.
- KC type.
- Mean keratometry.
- Pachymetry (thinnest point).
- Visual acuity (uncorrected and corrected).

Methods for obtaining information, statistical analysis, and ethical aspects

The information was obtained from the clinical records of each patient (sociodemographic variables, associated

diseases, symptoms, signs and refractive error, refractive cylinder, and visual acuity). Keratometry, pachymetry, and topographic data were obtained from the Pentacam device. The information was processed in the SPSS program, version 22, using descriptive and inferential statistics methods expressed in absolute frequencies and relative frequencies. Arithmetic means were obtained for mean keratometry, pachymetry at the thinnest point and refractive cylinder, at 2 time points: at the time of diagnosis and 3 years of follow-up. A one-way repeated measures analysis of variance, with adjustment of the confidence interval by Bonferroni correction, was used to establish the differences between the 2 time points of the study, as well as the p-value. The parents or guardians granted their consent for participation in the study, and the research was approved by the Bioethics Committee of the Institution. Surgical treatment with cross-linking was indicated to the patients studied, results that are part of future research.

Results

As shown in [table 1](#), the study was composed mainly of patients in the age group of 14-16 years (29.8%) followed by the group of 11-13 years (27.6%) and 17-18 years (23.4%). There was a predominance of males (60.6%), most of them from the city of Cuenca (48.9%) followed by Azogues (18.1%) and Cañar (9.6%).

As shown in [table 2](#), patients with allergic keratoconjunctivitis (45.1%) predominated, followed in order of frequency by patients with allergy (23.2%), atopic dermatitis (11.0%), and other diseases such as bronchial asthma (7.3%), strabismus (4.9%), penetrating corneal trauma (2.4%), as well as patients without diseases (6.1%).

Likewise, as shown in [table 3](#), patients consulted due to visual acuity decrease (68.1%), followed by patients with pruritus (12.8%), patients with frequent refraction variations (10.6%), and contact lens intolerance (8.5%).

[Table 4](#) shows that 48.9% of the cases had the scissoring reflex on examination, followed in order of frequency by 29.8% with prominent corneal nerves and 24.5% with the Munson's sign. Other signs, such as the Fleischer's ring and Vogt's striae, were observed less frequently.

[Table 5](#) shows that the refractive error that prevailed in the study was compound myopic astigmatism (64.4%) followed by mixed astigmatism (30.8%) and simple myopic astigmatism (4.8%). There were no patients with pure myopia or hyperopia in the sample studied.

In [table 6](#), we observe that 35.1% of the studied eyes presented an asymmetrical bow tie with skewed radial

Table 1. Distribution of patients according to sociodemographic variables (age, sex, place of residence). Medical Specialties Center Fundación Donum, Cuenca, Ecuador (2015-2018)

Age (years)	Frequency	Percentage
5-7	6	6.4
8-10	12	12.8
11-13	26	27.6
14-16	28	29.8
17-18	22	23.4
Total	94	100
Sex		
Female	37	39.4
Male	57	60.6
Total	94	100
Place of residence		
Cuenca	46	48.9
Azogues	17	18.1
Cañar	9	9.6
Guayaquil	7	7.4
Machala	5	5.3
Quito	3	3.2
Loja	3	3.2
Riobamba	3	3.2
Other	1	1.1
Total	94	100

Source: medical records.

Table 2. Distribution of patients according to the concomitant diseases. Medical Specialties Center Fundación Donum, Cuenca, Ecuador (2015-2018)

Concomitant diseases	Frequency	Percentage
Allergic keratoconjunctivitis	37	45.1
Systemic allergy	19	23.2
Atopic dermatitis	9	11.0
Asthma	6	7.3
Without diseases	5	6.1
Strabismus	4	4.9
Penetrating corneal trauma	2	2.4

Source: medical records.

axes topography pattern followed by an asymmetrical bow tie with inferior steepening (25.5%) and an irregular pattern (22.3%). About 17% (17.1%) of the patients presented an asymmetrical bow tie with the superior steepening pattern.

Table 3. Distribution of patients according to symptoms (reason for consultation). Medical Specialties Center Fundación Donum, Cuenca, Ecuador (2015-2018)

Symptoms	Frequency	Percentage
Slow and progressive visual decrease	64	68.1
Pruritus	12	12.8
Frequent change of refraction	10	10.6
Contact lens intolerance	8	8.5
Total	94	100

Source: medical records.

Table 4. Distribution of patients according to signs. Medical Specialties Center Fundación Donum, Cuenca, Ecuador (2015-2018)

Signs	Frequency	Percentage
Scissoring sign	46	48.9
Prominent corneal nerves	28	29.8
Munson's sign	28	24.5
Fleischer's ring	6	6.4
Vogt's striae	6	6.4

Source: medical records.

Table 7 shows a predominance of KC type 2 (25.5%) followed by type 3 (23.4%) and type 1 (19.2%). Less frequently, KCs type 5 (17.0%) and type 4 (14.9%) were also observed.

Table 8 shows a predominance of cases with an average keratometry between 45 and 49.9 D at the time of diagnosis. The predominance of this group was maintained at 3 years of follow-up. In addition, there was a decrease of cases with keratometry readings < 45 D at 3 years of diagnosis, with an increase of cases in the remaining groups: 50-54.9, 55-59.9, 60 D or more.

A statistically significant increase was observed between the average value of mean keratometry (49.6 D) at the time of diagnosis and the average value of mean keratometry at 3 years of follow-up (52.4 D). ($p = 0.02$; $\alpha = 0.05$) (Fig. 1).

As shown in table 9, at the time of diagnosis, there was a predominance of cases with pachymetry values between 480 and 499 μm ; however, after 3 years of follow-up, a greater number of cases with pachymetry values between 450 and 479 μm were observed. A statistically significant decrease was observed between the average pachymetry of the sample at the time of

Table 5. Distribution of patients by refractive defect. Medical Specialties Center Fundación Donum, Cuenca, Ecuador (2015-2018)

Refractive defect	Frequency	Percentage
Compound myopic astigmatism	121	64.4
Mixed astigmatism	58	30.8
Simple myopic astigmatism	9	4.8
Myopia	0	0
Hyperopia	0	0
Total (eyes)	188	100

Source: medical records.

Table 6. Distribution of patients according to the topographic patterns. Medical Specialties Center Fundación Donum, Cuenca, Ecuador (2015-2018)

Topographic patterns	Frequency	Percentage
Asymmetrical bow tie with skewed radial axes	66	35.1
Asymmetrical bow tie with inferior steepening	48	25.5
Irregular	42	22.3
Asymmetrical bow tie with superior steepening	32	17.1
Total (eyes)	188	100

Source: medical records.

Table 7. Sample distribution according to the classification by Fernández-Vega Alfonso. Medical Specialties Center Fundación Donum, Cuenca, Ecuador (2015-2018)

Keratoconus type	Frequency	Percentage
Phenotype 2	48	25.5
Phenotype 3	44	23.4
Phenotype 1	36	19.2
Phenotype 5	32	17.0
Phenotype 4	28	14.9
Total (eyes)	188	188

Source: medical records.

diagnosis (482 μm) and the average pachymetry of the sample at 3 years of follow-up (459 μm) ($p = 0.03$; $\alpha = 0.05$) (Fig. 2).

Table 10 shows a predominance of patients with a refractive cylinder between 2 and 4.9 D (41.0%) at the

Figure 1. Mean keratometry (sample average). **Figure 2.** Thinner point by pachymetry (sample average). **Figure 3.** Refractive cylinder (sample average).

time of diagnosis. At 3 years of follow-up, this group increases, as well as patients in the groups of 5-8 D and more than 8 D, at the expense of a decrease in patients with < 2 D of refractive cylinder. A statistically significant increase was observed between the average refractive cylinder of the sample at the time of diagnosis (4.6 D) and the average refractive cylinder of the sample at 3 years of follow-up (5.1 D) ($p = 0.01$; $\alpha = 0.05$) (Fig. 3).

Table 11 shows an increase in cases with visual acuity of $< 20/400$ at 3 years of follow-up, with a predominance at both time points of the study of patients in

Table 8. Distribution of patients according to the mean keratometry. Medical Specialties Center Fundación Donum, Cuenca, Ecuador (2015-2018)

Keratometry (diopters-D)	Diagnosis		3 years	
	Frequency	Percentage	Frequency	Percentage
< 45	25	13.3	9	4.8
45-49.9	113	60.1	114	60.6
50-54.9	24	12.8	29	15.4
55-59.9	19	10.1	24	12.8
60 or more	7	3.7	12	6.4
Total (eyes)	188	100	188	100

(p = 0.02; α = 0.05).

At diagnosis: mean 47.6; SD 0.67. At 3 years: mean 48.1; SD: 0.32.

Source: medical records.

Table 9. Distribution of patients according to the pachymetry (thinnest point). Medical Specialties Center Fundación Donum, Cuenca, Ecuador (2015-2018)

Pachymetry (μ m)	Diagnosis		3 years	
	Frequency	Percentage	Frequency	Percentage
> 500	12	6.4	7	3.7
480-499	73	38.8	57	30.4
450-479	55	29.3	66	35.1
400-449	39	20.7	45	23.9
< 400	9	4.8	13	6.9
Total (eyes)	188	100	188	100

(p = 0.03; α = 0.05).

At diagnosis: mean 477.2; SD 0.27. At 3 years: mean 468.1; SD 0.52.

Source: medical records.

Table 10. Distribution of patients according to the refractive cylinder. Medical Specialties Center Fundación Donum, Cuenca, Ecuador (2015-2018)

Refractive cylinder	Diagnosis		3 years	
	Frequency	Percentage	Frequency	Percentage
> 2.0	29	15.4	13	6.9
2-4.9	77	41.0	84	44.7
5-8	56	29.8	62	33.0
More than 8	26	13.8	29	15.4
Total (eyes)	188	100	188	100

(p = 0.01; α = 0.05).

At diagnosis: mean 4.8; SD 0.07. At 3 years: mean 5.1; SD: 0.12.

Source: medical records.

the group with a visual acuity between 20/400 and 20/100; in addition, a decrease in cases with uncorrected visual acuity > 20/100 is observed.

Table 12 shows a decrease in cases with corrected visual acuity > 20/40 at 3 years of follow-up. In addition, there is an increase in cases with visual acuity between

Table 11. Distribution of patients according to the uncorrected visual acuity. Medical Specialties Center Fundación Donum, Cuenca, Ecuador (2015-2018)

Uncorrected visual acuity	Diagnosis		3 years	
	Frequency	Percentage	Frequency	Percentage
< 20/400	23	12.2	29	15.4
Between 20/400 and 20/100	117	62.3	128	68.1
> 20/100 and < 20/40	42	22.3	29	15.4
Between 20/40 and 20/20	6	3.2	2	1.1
Total (eyes)	188	100	188	100

Source: medical records.

Table 12. Distribution of patients according to the corrected visual acuity. Medical Specialties Center Fundación Donum, Cuenca, Ecuador (2015-2018)

Corrected visual acuity	Diagnosis		3 years	
	Frequency	Percentage	Frequency	Percentage
< 20/400	7	3.7	11	5.9
Between 20/400 and 20/100	77	41.0	98	52.1
Greater than 20/100 and < 20/40	68	36.2	57	30.3
Between 20/40 and 20/20	36	19.1	22	11.7
Total (eyes)	188	100	188	100

Source: medical records.

20/100 and 20/400 and a higher frequency of cases with < 20/400, compared to the time of diagnosis.

Discussion

KC is a disease of young patients¹²⁻¹⁴. It usually appears in the second decade of life, although cases at a younger age¹⁵⁻¹⁸ have been reported. Therefore, the interest of the current study in highlighting the presence of the disease since childhood and our results agree with those that study KC cases with a presentation in the pediatric age¹⁹⁻²³. In the case of our study, they are patients who usually came to the office for different reasons: ophthalmological examination as a requisite to enroll in school, renewal of optical correction, family history of the disease, and parents request for corneal topography, among others.

Regarding sex, there is no consensus in the literature regarding whether the disease is more frequent in one or the other; different series report the disease in both sexes, without statistically significant differences between them^{12,19,20}. The disease is hereditary and there

are families where both male and female children inherit the disease²²⁻²⁴.

Pérez²⁵ reported that 59.7% of the patients corresponded to the female sex; the average age was 35 years, and by age group, the interval of 30-39 years was the most represented percentage, with averages of more or less similar ages by sex.

Marrero¹² reported that the most affected age group was that of 30-39 years (52.9%), followed in order of frequency by that of 20-29 (35.2%); while regarding sex, females predominated (58.8%). Refik¹³ showed an average age of 25 years without significant differences in terms of sex.

Regarding the place of origin of the study patients, for geographical reasons, most of the patients are from Cuenca, place where our institution is located, followed by regions adjacent to the city where there are no centers with the necessary technology for the diagnosis of KC by Pentacam. These patients belonging to other regions, including other provinces of the country, are referred by primary care physicians or by general ophthalmologists, with the objective of obtaining a specialized assessment and treatment customization.

Regarding associated diseases, the results obtained are similar to those reported in the existing studies of the disease. Pérez²⁵ reported that 26.4% had a disease, mostly corresponding to bronchial asthma and allergies (13.9% and 12.5%, respectively). Allergic keratoconjunctivitis (21.9%) was the most frequent ophthalmologic condition.

Regarding the symptoms and signs found, our data coincide with other studies such as the one from Pérez²⁵, which showed that half of the patients reported a slow and progressive visual decrease, and 34.7% changed frequently their optical correction. Symptoms such as pruritus and contact lens intolerance were described by 18.1% of patients. Pérez²⁵ reported as most frequent signs a conical cornea (38.3%), Munson's sign (33.6%), prominent corneal nerves (25.8%), and scissoring sign by retinoscopy (65.6%).

Refractive errors related to the disease and included in its clinical features are myopia and astigmatism. In the most frequent form, they appear as myopic astigmatism, mostly of the compound type. Myopia is due to a greater corneal curvature, given the conical shape that the cornea acquires, with curvatures that exceed 43 D, which increases the ocular refraction index and the focal point is formed in front of the retina. The presence of astigmatism is due to a distortion or alteration of the corneal meridians, in its anterior and/or posterior corneal curvature, which induces the presence of optical aberrations, especially in irregular astigmatism.

The current study supports international results on the subject, where these refractive defects are the most frequent²⁶⁻²⁹. Pérez²⁵ reported that compound myopic astigmatism was present ($p = 0.000$) in 85.2% of the eyes, while the remaining forms of astigmatism were infrequent, below 10%.

However, the second place in the frequency of mixed astigmatism should be highlighted, so the refraction sphere is positive. These are cases that have not been reported in the literature and were observed in the current study. The difference between the spherical components of the refraction depends on the location of the cone. There are KC with different corneal locations, and this can induce variations in the refraction sphere.

The corneal topography patterns obtained show a correspondence with the refractive errors found. The presence of asymmetrical bow tie with skewed radial axes in cases of lower asymmetric regular astigmatism reflects that most cone locations are inferior; however, we observed cases with superior asymmetries and corneal ectasia patterns with the presence of irregular astigmatism.

Corneal topography continues to be a fundamental pillar in the diagnosis of the disease, due to the comprehensive elements it provides, including pachymetry, keratometry, maps, anterior and posterior corneal curvatures indexes, as well as the possibility of performing an integrated analysis of coincidence or proximity of more steep sites with areas of greater thinning. In his study, Pérez²⁵ showed that according to the topographic pattern, irregular astigmatism was significantly higher ($p = 0.000$), often around 99.2%.

The advent and development of corneal topography have enabled the early diagnosis of the disease, which is why in the study sample we had cases with KC in the early stages, where there is still no evidence of corneal ectasia by topography; however, the comprehensive analysis of the topography plus the signs and symptoms allows diagnosis³⁰⁻³³.

The existence of several topographers (Pentacam) in our institution has allowed to perform this study so that patients with myopic and astigmatic refractive errors are examined in greater detail, and the disease can be suspected in its early stages, or the presence of fruste KC, with the possibility of long-term patient follow-up and the comparison of the first topography with subsequent ones, to corroborate the onset of the disease or its evolution, an aspect that acquires greater relevance in pediatric patients, in which an early diagnosis is necessary³⁴.

The Fernández-Vega classification is an analysis from the morphological perspective of the cone, aimed primarily for treatment with intrastromal rings^{35,36}. In this regard, it includes aspects such as cone location, the relationship between the three main diagnostic axes (flattest refractive, flattest topographic, and coma), orthogonality, symmetry and topographic aspect of the curvature map. In pediatric age, we obtained a predominance of phenotype 2 KC, which is characterized by its paracentral location, with a flattest topographic axis, not coincident with the coma axis, with an ectasia located more than 0.6 mm from the pupil center and a topographic appearance on the tangential map of asymmetric bow tie with inferior steepening (duck pattern). In addition, a predominance of phenotype three was also observed, with a paracentral location with a topographic "snowman" aspect. In this phenotype, there is perpendicularity between the axes, and two subtypes are defined. It is very likely that these morphological patterns will have variations in the future, considering the modification of the refractive, topographic, and coma axes. Due to this, longer-term studies are needed to evaluate these modifications (Fig. 4).

Type	Location	Proportion between axes	Orthogonal astigmatism	Astigmatism symmetry	Topographic aspect
1	Paracentral or pericentral	Refractive, topographic and coma coincident ($\leq 30^\circ$)	Irregular	Symmetrical	<i>Croissant</i>
2	Paracentral	Refractive flattest and coma mismatch ($> 30 < 60$)	Irregular	Asymmetric	<i>Duck</i>
3	Paracentral or pericentral	Perpendicular topographic and coma	Regular	Asymmetric	<i>Snowman</i>
4	Central	Not determinant	Irregular	Not determinant	<i>Nipple</i>
5	Central	Refractive and topographic match. Not determinant coma	Regular	Symmetrical	<i>Bow tie</i>

Figura 4. Keratoconus classification by Fernández - Vega A.

Keratometry values obtained in this study show the increase of corneal curvature in the disease, with results similar to those obtained previously by different authors, where all coincide in the increase of keratometry in KC, which is explained by the pathophysiological aspects of KC^{37,38}. Regarding keratometry power of the central cornea, Pérez²⁵ reports that the three keratometry groups follow the same distribution. Refik¹³ showed a decrease in mean keratometry, close to 6 months of crosslinking. The significant increase in mean keratometry in the study group exposes the evolution of the disease at this age, compared to other non-pediatric age groups.

As for the pachymetry values, in the disease, there is a corneal thinning, so the majority of patients have values below 500 μm . The results obtained coincide with other series of studies, which report values

between 400 and 500 μm . Perez²⁵ reported an average thickness of the central cornea of 493.2 μm , with values ranging between 485.6 and 500.8 μm . Refik¹³ reported a decrease in central corneal pachymetry compared to preoperative values 6 months after crosslinking. The existence of a group of patients with pachymetry values close to 500 μm reflects the diagnosis in the early stages of the disease. The significant decrease in pachymetry at the thinnest point obtained in the sample constitutes an important prognostic factor, analyzed in conjunction with variables such as the patient's age, refractive cylinder, and keratometry at the steepest point. In addition, the correspondence between the site of the steepest keratometry and the thinnest corneal point has great validity in the analysis.

KC is characterized by the presence of irregular astigmatism, so high refractive cylinders are expected

in the sample studied (even up to 8 D), which is a result similar to that obtained by other authors³⁹⁻⁴¹. The evolution of the refractive cylinder, with an increase during the 3 years of the study, is the expression of the corneal curvature modifications already described.

Marrero¹² reported an uncorrected visual acuity below 0.1 in 47.0% of the cases, and in 55.8% a visual acuity between 0.3 and 1, followed in smaller numbers by 32.3% of the subjects with values below 0.3 and 0.1. Pérez²⁵ reported an average uncorrected visual acuity of 0.1, and a corrected visual acuity of 0.6 ± 0.3 lines, with a significant increase in corrected visual acuity. Refik¹³ found a significant improvement in corrected visual acuity 6 months after crosslinking.

Undoubtedly, the most significant aspect of the analysis and discussion of the results obtained are the evolution of the disease. The way to evaluate this aspect includes the values of pachymetry, keratometry, and refractive cylinder by corneal topography. In the current study, the variables were reevaluated at 3 years, with statistically significant differences in the modifications of these variables, reaffirming the concept of the evolution of ectasia from an early age, an aspect that is further evidenced by the differences in acuity visual at diagnosis and 3 years of follow-up.

Although KC is diagnosed more frequently after puberty, the corneal ectasia process begins at a much younger age⁴². Pediatric KC (KC manifested in childhood [under 18 years of age] or adolescence [between 10 and 19 years]) has several unique characteristics. Studies have shown that pediatric KC shows a higher progression rate (88% of KC eyes) and a faster progression compared to adult KC^{20,39,43,44}. Léoni-Mesplé reported that pediatric KC was significantly more severe at the time of diagnosis, with 27.8% in Stage 4 versus 7.8% in the case of adults, and cases of KC evolved faster in children compared with adults²⁰. In addition, the biomechanical stiffness of the cornea is inversely related to age, and children with coexisting vernal keratoconjunctivitis are much more susceptible. Therefore, the progression of KC in children is aggressive and may not stop on its own^{26,37,40}. This can lead to progressive visual impairment in pediatric patients and affect their social and educational development and, therefore, negatively affect their quality of life^{45,46}.

The presence of astigmatism above two diopters in children with or without eye allergy, should constitute the criteria for direct screening by Pentacam, and according to the results, follow-up should be done every 6 months or annually with topography. The presence of

topographic patterns that show regular, orthogonal astigmatism with slight superior or inferior asymmetry, should prompt the follow-up of the case, even more so if it is already accompanied by suspicious values of some indices related to the disease and pachymetry values close to 500 μm . Treatment should be started even when there is a diagnosis without all topographic indices and with pachymetry values over 480 μm .

It is the duty of the ophthalmologist to explain to parents and/or guardians the importance of evaluating their children from an early age, especially if there is a family history of KC. These are aspects that are evident to the medical community of the specialty; however, they must be explained insistently.

Conclusions

- Pediatric KC was more frequent in male adolescents aged between 14 and 18 years, mostly from the city of Cuenca.
- Most of the patients presented allergic keratoconjunctivitis, systemic allergy, and atopic dermatitis, consulted for decreased visual acuity and pruritus with the presence of the scissoring sign, Munson's sign, and prominent corneal nerves.
- The predominant refractive defects were compound myopic astigmatism and mixed astigmatism with topographic patterns in an asymmetrical bow tie with skewed radial axes and asymmetrical bow tie with inferior steepening. Phenotypes 2 and 3 of the disease were identified more frequently.
- Visual acuity was maintained with a predominance between 20/100 and 20/400, with patients showing modifications of keratometry, refractive cylinder, and pachymetry, which suggest disease progression in this age group, over a period of 3 years.

Conflicts of interest

The authors declare that they have no conflicts of interest.

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Ethical disclosures

Protection of human and animal subjects. The authors declare that the procedures followed were in

accordance with the regulations of the relevant clinical research ethics committee and with those of the Code of Ethics of the World Medical Association (Declaration of Helsinki).

Confidentiality of data. The authors declare that they have followed the protocols of their work center on the publication of patient data.

Right to privacy and informed consent. The authors have obtained the written informed consent of the patients or subjects mentioned in the article. The corresponding author is in possession of this document.

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