Scientia Ricerca

Keratoconus and Ocular Dominance

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Abstract

Purpose: To analyse if the Keratoconus (KC) evolution develops casually in either eye or if the eye preference may play a role.

Methods: This observational, cross-sectional study was carried out in an outpatients unit. The study population included 45 patients (20 females, 25 males) aged between 15 and 64, average age 32.27 ± 12.24. The patients were subdivided on the basis of their eye preference and KC severity.

Results: The patients were subdivided on the basis of their eye preference and of the eye affected by KC at a more advanced stage, if bilateral. Of the 45 subjects with KC, 36 (80%) had it in the preferred eye or, if bilateral, the worse eye was the preferred one. When considering the distribution of KC severity its prevalence was found significantly higher in the preferred eye ($p < 0.0001$). In newly diagnosed patients the distribution of KC in the preferred eye was even higher ($p < 0.00005$).

Conclusion: The high prevalence and gravity of KC in the preferred eye, was surprising. It might be hypothesized that the eye dominance might play a role in the development of keratoconus but the mechanisms underlying this evolution are unknown. Possibly, the increased use of the preferred eye can influence, together with other factors, the corneal structure. This study is only observational and cannot give an explanation about the reason why such pathology arises or gives worse pictures in the preferred eye. Nevertheless, it can certainly give a new impulse to researches about ocular dominance and KC development.

Keywords: *Keratoconus; Ocular dominance; Preferred Eye; Progression; Aetiology*

Introduction

A large number of studies have been carried out in order to search for the origins of Keratoconus (KC) but, even today, the causes of such an alteration are still unknown. While in the Marfan syndrome, where there are similar structural changes in the corneal wall, the cornea is globally flatter, in the KC it takes on a steeper and ectatic aspect [1]. This leads to the supposition that, a part of an alteration of the biochemical and structural components of the cornea, there may be other factors that affects the aetiology of KC, therefore the cause of this structural corneal change is still unknown.

Having recently studied the importance of the preferred eye and of the monocular pathways in the widespread use of videogames [2], the authors thought about studying KC, starting from a completely different approach from that used until now. Therefore, they decided to analyse if the KC develops casually in either eye or if the eye preference may play a role.

Materials and Methods

Patients Population

This observational, cross-sectional study was carried out in an outpatient unit, accredited by the Italian Regional Health Service, run by the first two authors (GD and CR). All consecutive patients who attended the eye unit, either for routine examination or because of visual symptoms, with a diagnosis of KC, were recruited between the beginnings of 2009 until May 2017.

One patient who presented KC was excluded, as he was also affected by bilateral deafness, severe myopia and was slightly mentally retarded, thinking that this case of KC might be part of a syndrome.

The authors considered the ethical aspects of the study and followed the guidelines of the Helsinki Declaration. The study was approved by the institutional review board of the Department of Experimental Medical- Surgical Sciences of the University of Messina, Messina, Italy.

The study population included 45 patients (20 females, 25 males) aged between 15 and 64, average age 32.27±12.24. The age distribution, in the two sexes was homogeneous (females from 20-35 years, average age 35.85±12.27, males aged 15-63, average age 29.4 ± 11.66) (F-Fisher Test = 0.80; NS).

Tests performed

All patients underwent both ophthalmological and orthoptic examinations, in addition to their physiological, pathological and ophthalmological history. The orthoptic evaluation included ocular motility, identification of the preferred eye using Dolman method [3], cover test for near and distance vision, using Lang-Fixation Cube as a target for near fixation, and Four Diopter Prism Base-Out Test [4]. Stereopsis was tested with Lang-Stereotests I and II (LANGSTEREOTEST AG, Küsnacht, Switzerland) [5]. The possible results for Lang-Stereotest I and II are: positive (correct localization and naming of 2 out of 3 hidden objects), negative (no object can be detected), doubtful (only one hidden object is localized and named correctly).

The assessment of refraction was carried out using the autorefractometer Topcon KR8100P (Topcon Italia, Paderno Dugnano (MI), Italy), taking at least five measurements for each eye, before the evaluation of subjective monocular visual acuity with optotypes at 3 metres distance, both in the accomodating eye and in cycloplegia. The latter was obtained by means of cyclopentolate (1%) instilled twice at an interval of ten minutes and performed after 20 min wait. Astigmatism was defined as any refractive error with a cylindrical component of ±0.50 D or higher. Any accomodating eye requiring correction with a spherical component of +0.50 D or higher to reach 10/10 was defined as hypermetropic. The study of ocular surface and anterior segment was carried out with the Topcon Slit Lamp 3E (Topcon Italia, Paderno Dugnano (MI), Italy) and the examination of the fundus by direct (Heine Miroflex H2, Heine Optotechnik, Herrshing, Germany) and indirect ophthalmoscopy (Heine Sigma 150, Heine Optotechnik, Herrshing, Germany).

The corneal map for KC assessment was carried out by the autorefractometer KR8100P (Topcon Italia, Paderno Dugnano (MI), Italy).

Data about the start of the symptoms and/or the time of the diagnosis of KC, in cases where the patient was already aware of the disease, were collected.

Statistical analysis

The data obtained were collected and stored on a computer database (Excel 2013). The IBM Statistical Package for Social Sciences (International Business Machines Corp. New Orchard Road Armonk, New York 10504) was used for analysing data. The Chi-Square test and the F-Fisher test were applied for the quantitative comparisons and a $p<0.05$ was considered statistically significant.

Results

The distribution of the refractive errors and stereopsis among patients were reported in table 1 and 2. Considering the whole population, 21 had the right eye as preferred while 24 the left one.

Eye Refraction (90 eyes)	KC Present 75	KC Absent 15
Simple Miopic Astigmatism	12	5
Simple Hypermetropic Astigmatism	2	0
Compound Miopic Astigmatism	50	6
Compound Hypermetropic Astigmatism	0	2
Mixed Astigmatism	11	2

Table 1: *Distribution of Refractive Errors in Patients Population*

Stereopsis (45 subjects)	Positive response	Negative response
Lang Stereotest 1	22	23
Lang Stereotest 2	24	21

Table 2: *Stereopsis data in Patients with Keratoconus.*

Of the 45 patients included, 15 (3 Female and 12 Male) showed monocular KC; 30 had binocular KC (17 Female and 13 Male). See tables 3 and 4.

	Females		Males	
	KC Right Eye	KC Left Eye	KC Right Eye	KC Left Eye
Preferred Right Eye	2	0	2	1
Preferred Left Eye	0	1	2	7

Table 3: *Patients with Monocular Keratoconus Divided, according to Sex, on the Basis of the Preferred Eye.*

	Eye with more severe KC			
	Females		Males	
	Right Eye	Left Eye	Right Eye	Left Eye
Preferred Right Eye	6	3	7	1
Preferred Left Eye	1	7	1	4

Table 4: *Sample Distribution of Patients with Bilateral Keratoconus Divided According Eye Preference and Keratoconus Severity.*

The presence of KC in the preferred eye was demonstrated in 36/45 patients (80%). In this group were included both monolateral KC and bilateral KC, where the worse clinical picture was in the preferred eye [6, 7]. The statistical analysis of these results was highly statically significant (p<0.0001) (Table 5).

	Right Eye	Left Eye
Preferred Right Eye	17	5
Preferred Left Eye	4	19

Chi-square Test = 13.88; p<0.0001

Table 5: *Distribution of More Severe Keratoconus in the Preferred Eye.*

Furthermore, considering only the patients whose diagnosis of KC was first made by the Authors (27/45), the eye more affected by KC was the preferred eye with an even greater prevalence (24/27 = 88.9%, p<0.00005) (Table 6).

	Right Eye	Left Eye
Preferred Right Eye	11	1
Preferred Left Eye	2	13

Table 6: *Distribution of More Severe Keratoconus*
and Eye Preference in Newly Diagnosed Patients.

Discussion

The high incidence and gravity of KC in the preferred eye, is surprising. Why does this pathology affect first the preferred eye and, when binocular is worse in the preferred eye?

Why is the preferred eye more vulnerable to the noxa that causes the alteration of the corneal structure?

It can be hypothesized that in the preferred eye there is a function or a mechanism, more activated than in the non-preferred eye. When this is altered, it may cause corneal structural alterations.

It is interesting to underline that the greater incidence of KC in the preferred eye is even more remarkable in subjects with a new KC diagnosis (p < 0.00005). In cases when the KC determines a profound impairment of visual function, this may result in changes of ocular dominance. This is what it was seen in three cases studied prospectively where, with KC worsening, it was observed a shift in ocular dominance.

This is easily understood because the brain, instead of forcing itself to look with an eye whose image becomes increasingly un-focused and distorted, changes the eye preference. This change of ocular dominance is the same as the mechanism that forces the brain to look with the ambliopic eye during anti-ambliopia treatment, penalizing the image of the preferred eye in order to obtain an improvement of the contralateral eye.

This is a further demonstration of how our visual system remains plastic well beyond the "sensitive period" of brain development and of how it adapts to every successive change, always trying to find the most valid solution with the least effort [8-10].

Because of this, in the patients population who have been affected by this disease for several years (for example in cases needing surgery) it is probable that the link between the preferred and the worst eye affected by KC is no longer clear, since in the meantime the brain has already changed ocular dominance.

This study is only observational and cannot give an explanation about the reason why such a pathology is worst in the preferred eye. Nevertheless, it can certainly give a new impulse to researches about ocular dominance and KC development.

Future research tasks, should attempt to discover: 1) which mechanisms are activated mainly in the preferred eye compared with the non-preferred one; 2) which are the structures involved; 3) in what ways these might influence the integrity and health of the cornea.

The answer to these questions might bring to a better knowledge of the mechanisms underlying ocular dominance and KC aetiology.

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