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Assessment of corneal topographic patterns and densitometric parameters in patients with severe delayed-onset mustard gas keratopathy and patients suffered from corneal scarring

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Abstract

Purpose: This study was performed to evaluate the densitometric values and the type of corneal topographic pattern extracted from Pentacam HR (OCULUS, Wetzlar, Germany) in two groups of severe delayed-onset mustard gas keratopathy (DMGK) and old herpes simplex corneal scarring.

Materials and methods: Twenty eyes of each group were enrolled to the study and were examined using the Pentacam HR. Total corneal densitometry was measured over a 12 mm diameter area, divided by annular concentric regions and depths. Also, the corneal topographic pattern from the axial curvature map of the anterior corneal surface was determined in all patients.

Results: The most common observed patterns in severe DMGK and old corneal scarring were superior steepening and irregular pattern, respectively. Densitometry measurement in 10 to 12 mm in diameter in DMGK was significantly higher than old corneal scarring.

There were not any significant differences in other densitometry values between the groups.

Conclusion: It seems that clinical evaluation of corneal structure using Pentacam can improve our knowledge about this rare mustard gas keratopathy.

Keywords: Delayed-onset mustard gas keratopathy; Corneal scarring; Pentacam HR; Densitometry; Corneal pattern.

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Background

Mustard gas (MG) is a vesicant and alkylating chemical agent that damages the living tissues that exposed to air, such as the skin, mucous membranes, eyes, and respiratory tract [1]. In World War I in 1917, MG was first used as a weapon of mass destruction and the most recent use of this agent was in Iraq-Iran war, where it was used against Iranian forces [2,3]. Approximately 75 to 90 percent of people exposed to MG suffer from eye problems, and the severity of involvement depends on the amount of exposure to the agent [4,5]. Mustard gas eye injuries have observed in both early and late forms. Early lesions in the form of photophobia, tearing, conjunctival hyperemia, blepharospasm, chemosis, corneal abrasion, and anterior uveitis are seen immediately in exposed individuals. In some cases, lesions heal after a few weeks (acute form), but in others, they remain as a permanent inflammation (chronic form). Delayed effects of MG have seen after a period of incubation (1 to 40 years) following initial contact and known as delayed-onset mustard gas keratopathy (DMGK). Depending on the severity of the damage, it is classified as mild, moderate, and severe forms, that includes a wide range of eye problems (Table 1) [5,9].

There are about 100,000 individuals who have been chemically injured in Iran, and approximately 0.5% of them suffer from DMGK [10,11]. Although there have been several studies of DMGK in terms of signs and symptoms, surgical procedures, pharmacology, and biomechanical parameters [12,15], the pathophysiology of progressive ocular changes in this keratopathy is not well known [16]. To reach a better knowledge of corneal structure in patients with severe DMGK, we evaluated the densitometric values and also topographic patterns of the cornea using the Pentacam high resolution (HR) (OCULUS, Wetzlar, Germany) in these rare patients. Additionally, these parameters and patterns were assessed in another group with corneal scarring resulted by herpes simplex. Which, in this keratitis, recurrent infections cause fibrosis and neovascularization and this condition eventually leads to corneal scarring and opacity [17]. This study followed a study conducted by Jadidi et al [15]. That, they evaluated the corneal biomechanical parameters in eyes with corneal scarring due to herpes simplex and eyes with severe DMGK using Corvis ST. They mentioned that the biomechanical properties of the cornea were different in these two groups and corneal stiffness was lower in the severe DMGK group. Because of the few studies and the limited number of chemical victims with severe DMGK who have not undergone corneal transplantation, this study may be useful in understanding the corneal structure of these elderly and rare patients.

Material and methods

This cross-sectional study was conducted at the vision health research center in Tehran-Iran. The study was approved by the Ethics Committee of Baqiyatallah University of Medical Sciences (IR.BMSU.1399.060), and the research followed the tenets of the Declaration of Helsinki. Twenty eyes of 14 patients (12 males / 2 females) who had been exposed to mustard gas during the Iran-Iraq war between 1980 and 1988, were entered into the study as the first group after confirmation of severe DMGK by a same ophthalmologist (Kh. J). Figure 1 shows an eye with severe DMGK. The second group consisted of 20 eyes of 19 patients (16 males / 3 females) with grade 2 or 3 of corneal scarring due to herpes simplex. The grading system of the corneal scar is illustrated in Table 2 [18]. Exclusion criteria were a history of any eye surgery, systemic eye diseases, glaucoma, uveitis, active eye infection, and using any contact lenses. All patients with severe DMGK had a history of punctal occlusion.

Measurements

All participants underwent slit-lamp and fundus examination. All examinations performed between 4 PM and 8 PM. The written consent was received from patients before the test, and the procedure was described. After the patient was seated and his chin positioned, we asked them to look at the red light inside the device. The system automatically scanned the scheimpflug images of the cornea, which took approximately 2 seconds for each eye [19].

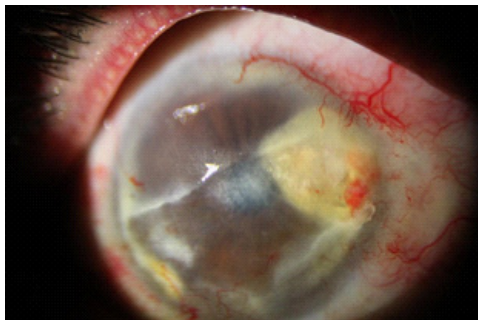

Figure 1: The eye of a patient in the delayed-onset mustard gas keratopathy group. The patient was injured 30 years ago and suffered from severe photophobia, meibomian gland dysfunction and blepharitis. Lipid and amyloid deposition, vascular tortuosity, corneal thinning and scarring are seen in the cornea.

The Pentacam HR has a rotating scheimpflug camera and a static camera that captures numerous images of the anterior segment of the cornea. The scheimpflug camera rotates around the optical axis with a monochrome linear light source and scans the cornea from zero to 180 degrees. The static camera in the center is used for pupil control and maintaining the fixation [19].

After controlling the quality of captured images by Pentacam, in both patient groups, eight parameters of corneal densitometry map were extracted. In this map, a region of 12 millimeters of the cornea was divided into four concentrated areas to achieve a local densitometry analysis. The first region was the central zone with a diameter of 2 mm, which is centered at the corneal apex. The second, third, and fourth annulus expanded from 2 to 6 mm, 6 to 10 mm, and 10 to 12 mm in diameter, respectively. Also divided by layers: anterior (120 microns), central (is demarcated by subtraction of the anterior and posterior layers from the total thickness), and posterior (60 microns) layers [20]. In this study, we evaluated the total corneal densitometry values in these rings and layers, and also, the total corneal densitometry in both groups. As well as, the observed topographic pattern from the axial curvature map (Sagittal) of the anterior corneal surface in each patient was recorded. Corneal topography patterns were classified based on the 10 patterns proposed by Rabinowitz et al. [21] (Figure 2).

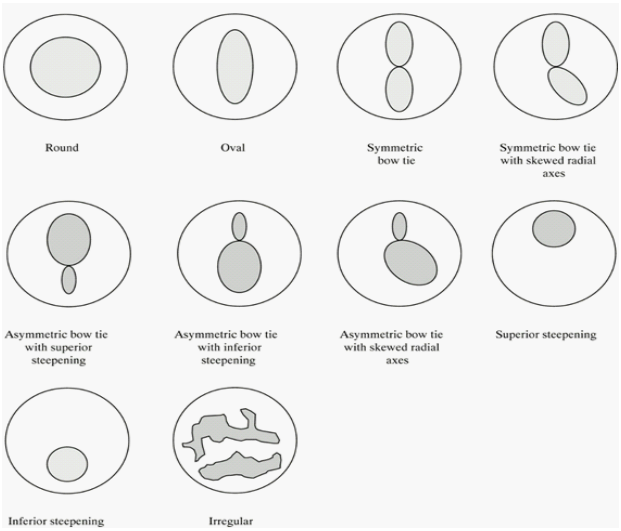

Figure 2: Corneal topography patterns based on the 10 patterns proposed by Rabinowitz et al.

Statistical analysis

In this study, SPSS software version 20 (SPSS for windows, Chicago, IL) used for statistical analysis. Two-independent samples test and the Mann-Whitney U test were used to compare the measurements obtained by the Pentacam HR scheimpflug system between groups. For all examinations, probability values below 0.05 were considered as significant values. Also, the prevalence percentage of observed corneal topographic patterns in each group was measured.

Results

Twenty eyes of 14 patients (mean age = 53.25 ± 5.95 years) who suffer from severe DMGK and 20 eyes of 19 patients (mean age =54.40 ± 17.20 years) with the herpes simplex corneal scarring were enrolled to study. We analyzed the data in terms of corneal topographic patterns and densitometry values in two groups.

Corneal topographic patterns

Table 3 represents the type and prevalence of corneal pattern in each group. As can be seen in this table, the most common patterns in the patients with severe DMGK and herpes simplex corneal scarring were superior steepening (75%) and irregular patterns (55%), respectively.

Corneal densitometric parameters

Densitometry measurement at a diameter of 10 to 12 mm in severe DMGK was significantly higher than in corneal scarring (severe DMGK = 44.62 ± 11.62, corneal scarring = 27.46 ± 10.76, p=0.004). Table 4 shows that there is no significant differences in other densitometry values between the groups.

Discussion

We know that mustard gas damages the cornea, and to the best of our knowledge, up until the present, some studies have been evaluated the structure of cornea with DMGK. Corneal biomechanical parameters were measured in two studies by Jadidi et al [15] and Naderi et al [22]. As well as, clinical and confocal microscopic findings have been reported in these veterans [12,16,23-26]. But we did not find any studies on topographic and densitometric properties in these patients. Therefore, this study aims to provide insight into these parameters in the DMGK.

In a reviewing the corneal patterns, we found that in the chemically injured group, the superior steepening pattern was the most common (Figure 3), while the irregular pattern was the most common in the group of patients with corneal scarring (Figure 4). Pleyer et al. stated that the parts of the eye that are located in the palpebral fissure are the most damaged during the MG exposure [24]. And, the results of a study conducted by Balali et al. showed that corneal thinning and melting might be higher in the peripheral and inferior corneal regions. Based on these knowledges [27], it can be said that the corneal melting of the corneal inferior part may show the superior part steeper than other areas and create a pseudo-superior pattern. On the other hand, our findings showed that this pattern is different from the one is seen in the superior keratoconus. According to the survey by Prisant et al. [28] in this rare keratoconus, a marked superior corneal protrusion, corneal thinning, and a

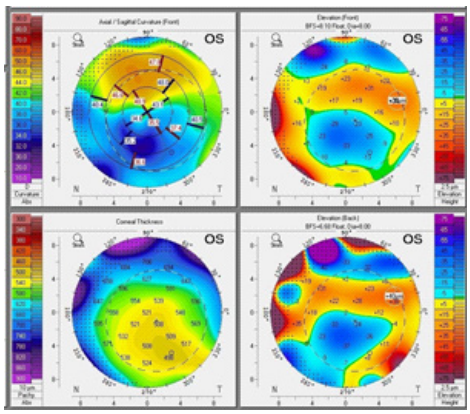

Figure 3: An example of pseudo-superior pattern observed in the severe delayed-onset mustard gas keratopathy group.

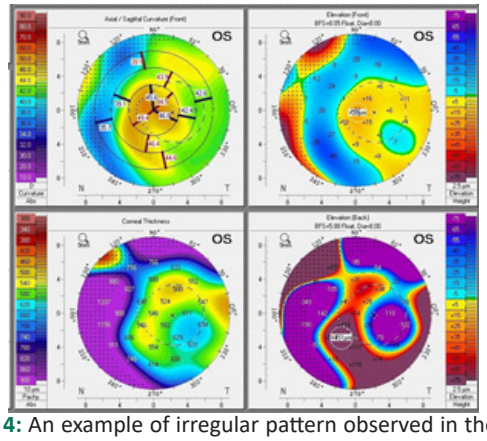

Figure 4: An example of irregular pattern observed in the old corneal scarring group.

Table 1: Classification of delayed-onset mustard gas keratopathy.

Grading	Signs and symptoms
Mild	Photophobia, burning and foreign body sensation in eye, dry eye and tearing, chronic blepharitis and conjunctival vascular changes.
Moderate	Features of the mild stage plus mild to moderate limbal ischemia, corneal irregularities, thinning and corneal opacity, neovascularization around the cornea, corneal stromal scarring and a decrease in the corneal sensation.
Severe	Photophobia, pain and severe vision loss, severe ischemia and limbal cell deficiency, central and peripheral corneal opacity due to lipid and amyloid deposition, corneal vascularization in the central and peripheral area, band keratopathy, central and peripheral corneal scarring (mostly in the inferior), intra corneal hemorrhage in the central and peripheral area, corneal ulcer, corneal melting and perforation.

Table 2: Classification of corneal scarring.

Grade	Descriptors for overall scarring
1.0	Trace and not on Line of Sight, <1.5 mm total size
2.0	Easily noticeable and approaching Line of Sight, 1.5-2.5 mm total size
3.0	Dense but translucent and impinging on Line of Sight, total size 2.5 mm or greater
4.0	Opaque and on Line of Sight, size 2.5 mm or greater

Table 3: Type and prevalence of corneal topographic patterns in two groups.

Groups	Patterns and percentage
Severe DMGK	Superior steepening (75%) Irregular (25%)
old corneal scarring	Irregular (55%) Asymmetric bowtie with inferior steepening (25%) Superior steepening (20%)

Table 4: Total densitometry values in the different layers and annulus of cornea in two groups.

Variables	Group1, DMGK	Group 2, Corneal scarring	*P*	Group 1 vs.2
Anterior Layer Mean (sd)	53.80(13.67)	40.77(14.22)	<0.001[a]	0.17
Central Layer Mean (sd)	26.96(5.02)	24.62(7.91)	<0.001[a]	0.406
Posterior Layer Mean (sd)	16.77(5.74)	19.1(8.54)	<0.001[a]	>0.99
0-2 mm Annulus Mean (Sd)	28.37(7.63)	32.47(11.32)	<0.001[a]	>0.99
2-6 Mm Annulus Mean (sd)	27.03(6.51)	26.45(8.55)	<0.001[a]	>0.99
6-10 mm Annulus Mean (sd)	37.07(8.2)	27.75(11.03)	<0.001[a]	0.061
e10-12 mm Annulus Mean (sd)	42.62(11.62)	27.46(10.76)	<0.001[a]	0.004[a]
Entire of Cornea Mean (sd)	32.5(5.61)	28.01(8.15)	<0.001[a]	0.244

scar at the cone apex are seen. Whereas, in the superior part of the cornea with severe DMGK, there are no protrusion and thinning. So, this particular pattern can be an indicator for the eye with severe DMGK.

Based on the study of Dhobhghaill et al. [20] densitometry is an indicator for the evaluation of corneal opacity in different depths and layers. The study of densitometric findings in the two groups revealed different areas of dense opacity in the cornea. In the DMGK group, the peripheral part had the most opacity, which can be thought.

Conclusion

The clinical findings gained from this study using Pentacam may provide new insights about the corneal structure in the rare patients who suffered from severe DMGK.

Declaratons

Acknowledgment: Not applicable.

Competing interest: The authors declare that they have no competing interests.

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