Egypt. J. Chem. Vol. 67, SI: M. R. Mahran, pp. **1887 - 1890** (2024)

Egyptian Journal of Chemistry

http://ejchem.journals.ekb.eg/

Case Study: Optical Rehabilitation Remedies for a Patient with Keratoconus and Esophoria with Biochemical Aspects

Ahmed Ibrahim Ali Al Ibrahim[1], Almothana Makki Ali Aboalqasim[2], Laila Abdurhman Namazi[3], Manal Mohammed Tawashi[3], Mohammed Yahya Faqihi[3], Rawan Farhan[3], Albndari Ali Albayshi[3]

1 Consultant Optometrist, Ministry of Health, Saudi Arabia
2 General physician, , Ministry of Health, Saudi Arabia
3 Optometrist, Ministry of Health, Saudi Arabia

Abstract
Keratoconus and esophoria are eye disorders associated with eye alignment that affect children and teenagers. However, keratoconus may not be noticed at a tender age, while esophoria can be identified early in childhood. Keratoconus results from corneal thinning and gradual outward swelling, forming a cone-like shape. Biochemically, this condition is linked to changes in the extracellular matrix, including collagen degradation and altered oxidative stress levels, which weaken the corneal structure. Esophoria is associated with weak eye muscles that cause the eye to turn inward. This misalignment is influenced by disruptions in neurotransmitter signaling and neuromuscular coordination, which affect the convergence process. Individuals with esophoria may not easily notice the condition, as the eyes appear to work together until the fusion, or binocular vision, between the two eyes is broken..

Keywords: Rehabilitation Keratoconus Esophoria Biochemical Aspects.

.

1. Introduction

Keratoconus is the resultant condition when the cornea becomes thin and progressively swells outward into a cone shape. The resultant shape causes blurred vision and can sometimes cause sensitivity to bright light [1]. Other symptoms include double vision when looking with one eye, triple ghost images, and blurry vision that makes driving difficult. However, the disorder affects both eyes; in most cases, it affects one eye more than the other. Strabismus was more common, and binocular vision was impaired in people with keratoconus [2]. Esophoria is an inward deviation of an eye that occurs when binocular vision between the two eyes is disrupted, making the eyes fail to focus on a single object. Weak eye muscles or issues causing esophoria with the nerves that transfer messages to the eye muscles. It occurs due to undeveloped eye muscles. It can affect any gender at any age, though its cause is related to childhood and the development of eye muscles. Some adult patients with long-term asymmetric keratoconus experience loss of binocular function [3].

Biochemistry of Keratoconus:

Keratoconus is a progressive, non-inflammatory disorder of the cornea characterized by thinning and ectatic deformation, leading to visual impairment. At the biochemical level, keratoconus involves changes in the extracellular matrix (ECM) of the cornea, specifically in the degradation and remodeling of collagen fibers, which are crucial for maintaining the corneal structural integrity. The primary biochemical alterations include the upregulation of enzymes such as matrix metalloproteinases (MMPs), which contribute to the breakdown of collagen and proteoglycans in the corneal stroma. This degradation results in a reduction of the collagen fibrils' cross-linking, weakening the corneal structure.

Additionally, an imbalance in the synthesis and degradation of glycosaminoglycans (GAGs), such as keratan sulfate, has been observed. This imbalance disrupts the corneal hydration and structural properties. Recent studies have also implicated oxidative stress, with an increased production of reactive oxygen species (ROS), which exacerbates the damage to corneal cells, collagen, and other ECM components. The enzymatic activity of lysyl oxidase, which is responsible for collagen cross-linking, is also reduced in keratoconic corneas, contributing further to the loss of biomechanical stability. Genetic factors, including mutations in the collagen and other ECM-related genes, have been identified as important contributors to the pathogenesis of keratoconus.

*Corresponding author e-mail: opt.ahmed@hotmail.com (**Ahmed Ibrahim Ali Al Ibrahim**)
Receive Date: 18 December 2024, Revise Date: 28 December 2024, Accept Date: 31 December 2024
DOI: 10.21608/ejchem.2024.345498.11006

Biochemistry of Esophoria:

Esophoria is a type of heterophoria, a condition where there is a latent inward deviation of the eyes that is controlled by fusion mechanisms under normal conditions. The biochemistry of esophoria involves the complex coordination between the sensory and motor systems of the eyes, mediated by neural pathways and biochemical signals that regulate ocular alignment and convergence. At the biochemical level, neurotransmitters such as acetylcholine play a crucial role in the neuromuscular control of eye movement, affecting the coordination between the medial and lateral rectus muscles, which are responsible for convergence. Disruptions in the signaling pathways, particularly in the function of the oculomotor nerve or its neuromuscular junctions, can lead to imbalanced convergence, contributing to esophoria. Additionally, the biochemical regulation of the vestibular system and proprioception plays a role in eye alignment, as any dysfunction in the proprioceptive signals or the neural feedback loop from the extraocular muscles can exacerbate the condition. Changes in the function of the brainstem, particularly in the convergence center of the midbrain, may also contribute to the onset or progression of esophoria. Imbalances in neurotransmitter levels or receptor activity, including those related to serotonin and dopamine, can affect the processing of visual input and the ocular motor response, influencing the development and management of esophoria.

Case Report

History

A 22-year-old male was referred for an eye test. The patient's chief complaint was esophoria, with the primary symptom being an inward eye deviation at some moments. He was also affected by keratoconus, with the primary symptom being blurriness in both eyes; however, one eye was more affected than the other. He has experienced blurred vision since he was ten years old, with much progression within his 21st and 22nd years of life. His parents declared that the child was born normally and that there was no forceps delivery. The patient argued that he had experienced the effect since childhood, often occurring when reading. At four years of age, the patient was given glasses since he constantly complained about unclear vision. The patient declared that he never rubbed his eyes, there was no family history of keratoconus or inflammation, and he was not tested for associated disorders. He occasionally had double vision and eyestrain and experienced difficulty when reading.

Measurements

Entrance Tests, Refraction, and Binocularity

The patient was subjected to the cover-uncover test. The eye deviated during the cover test. Afterward, the patient was subjected to a prism cover test to gauge the degree of the eye misalignment. This was done at near-distance 30 centimeter (cm) and distance testing 6 meter (m). This was necessary to identify the right phoria. A counter test was done on the uncovered eye.

During the cover–uncover test, the eye deviated at -3 prism diopters (PD) vertical in near testing and -4 PD vertical in far testing. During horizontal testing, the eyes indicated -8 PD in near and -14 PD in far testing. The patient indicated that he sometimes saw double objects during the testing process. There was no rotary component. The pupils had no apparent pupillary defect; they were all equal, round, and refractive to light. All the cranial nerves were intact and symmetric. Through the cover–uncover test, the patient was found to have an inward phoria (esophoria).

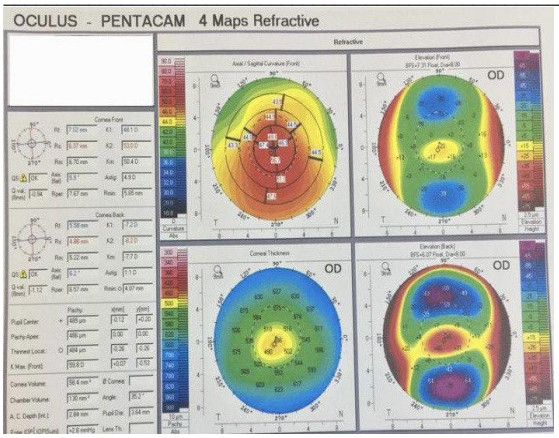
Biomicroscopy and Optical Coherence Tomography (OCT)

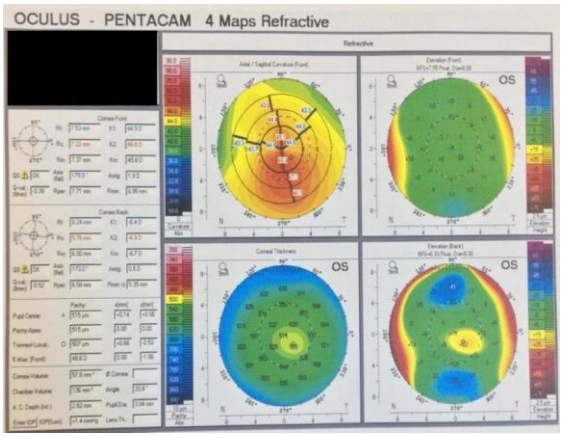
Biomicroscopy (anterior segment) indicated minor corneal thinning inferior to the pupil in both eyes. The right eye had a minimum keratometry reading of 48.1 diopters (D). The left eye had 44.9 D. The maximum keratometry readings were 53 D in the right eye and 45.9 D in the left eye. Corneal pachymetry at the thinnest locations was 484 microns in the right eye and 507 microns in the left eye. Summary of the Corneal Topography and Pachymetry Data (Keratoconus)

	Right Eye	Left Eye
Simulated Keratometry (Minimum Curvature)	48.1D	44.9D
Simulated Keratometry (Max Curvature)	53D	45.9D
Pachymetry (Thinnest)	484 microns	507 microns

Summary of the Results (Esophoria)

Tested	Values in Prism Diopters (Pd)	Standard Deviation in Pd
Esophoria (vertical at a distance of 6 m)	2	0.05
Esophoria (vertical at a Near Distance of 30 cm)	3	6.1
Esophoria (horizontal at near distance of 30 cm).	-15.7	3.7
Esophoria (horizontal at a distance of 6 m)	9	0.69





Corneal Topography Findings of the Right Eye of the Patient (Keratoconus) Picture

Diagnosis

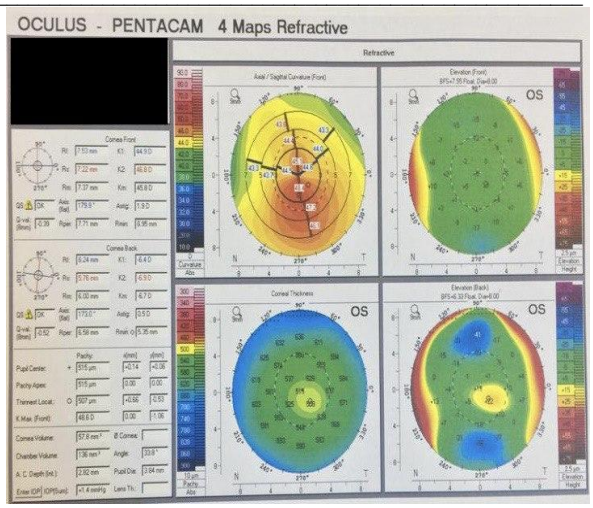
The patient was found to be affected by esophoria and keratoconus after putting into consideration all the clinical findings. This was done by evaluating all risk factors that were known by the patient before the examination. He was affected by latent esophoria. This is a phoria that was only identified during the uncover test.

Treatment

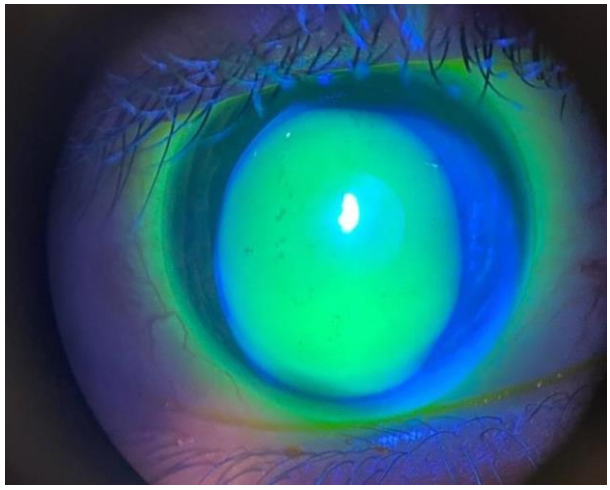
The patient was subjected to eye therapy. This was necessary to strengthen the patient's eye muscles, consequently reducing eye fatigue and strain. He was afterward offered glasses that help control esophoria. This was a latent esophoria, occurring only occasionally, that is only identifiable when an eye is uncovered.

Keratoconus Treatment

The patient was further subjected to collagen cross-linking treatment to cease the keratoconus condition from worsening. According to Fasciani et al. [4], collagen cross-linking treatment is necessary, as it prevents the condition from progressing to risky levels that may require surgical processes, such as cornea transplants. He was then fitted with hard, gas-permeable contact lenses to aid in the restoration of perfect vision.



Corneal Topography Findings of the Left Eye of the Patient (Keratoconus)Picture



Corneal Topography Findings of the Left Eye of the Patient (Keratoconus) Corneal Topography Findings of the Left Eye of the Patient (Keratoconus)

Discussion

Phoria can either be convergent or divergent. Divergence insufficiency is an esotropia at long distance with a weaker esophoria at near distance [5]. Convergence insufficiency is an esotropia at a near distance with a weaker esophoria at a long distance [6]. Esophoria occurs as a result of undeveloped eye muscles or when there is a problem with the nerves that send messages to the muscles. The presence of esophoria in a patient is tested through various methods, such as the cover–uncover test, prism cover test, and cross-cover test. In the subject case in question, the cover–uncover test was done to identify whether there was any deviation. Afterward, a prism cover test was done to measure the magnitude of the misalignment. The patient was diagnosed with esophoria and subjected to vision therapy to improve his eye muscle strength and reduce eyestrain and fatigue.

Conclusion

As with this case, esophoria can occur at the same time with other eye conditions such as keratoconus. A comprehensive testing and consequent treatment are necessary to restore the patient's eye health effectively.

References

[1] Tsang, D. K., Spors, F., Shen, J., McNaughton, L. E., & Egan, D. J. (2018). Optical Rehabilitation of a Patient with Keratoconus and Nystagmus. Medical Hypothesis, Discovery and Innovation in Ophthalmology, 7(4), 183.

[2] Antunes-Foschini, Rosália MS, et al. "Oculomotor status, binocular vision, and stereoacuity in a series of keratoconus subjects." Investigative Ophthalmology & Visual Science 59.5 (2018): 1869-1877. https://doi.org/10.1167/iovs.17-23484

[3] Sherafat, H., White, J. E. S., Pullum, K. W., Adams, G. G. W., & Sloper, J. J. (2001). Anomalies of binocular function in patients with longstanding asymmetric keratoconus. *British Journal of Ophthalmology*, *85*(9), 1057–1060. https://doi.org/10.1136/bjo.85.9.1057

[4] Fasciani, R., Crincoli, E., Fedeli, C., Rebecchi, M. T., Senneca, M., Mosca, L., ... & Rizzo, S. (2022). Binocular Visual Function Changes After Corneal Collagen Cross-linking in Patients With Keratoconus. Cornea, 10-1097.https://doi.org/10.1097/ICO.0000000000003053

[5] Li, Y. P., & Zhang, W. (2017). Advances in research of divergence insufficiency. [Zhonghua yan ke za Zhi] Chinese Journal of Ophthalmology, 53(7), 552-556.(10.3760/cma.j.issn.0412-4081.2017.07.016)

[6] Scheiman, M., Alvarez, T. L., Cotter, S. A., Kulp, M. T., Sinnott, L. T., Plaumann, M. D., ... & Convergence Insufficiency Treatment Trial Investigator Group. (2021). Negative fusional vergence is abnormal in children with symptomatic convergence insufficiency. Optometry and vision science: official publication of the American Academy of Optometry, 98(1), https://doi.org/10.1097/opx.0000000000001626

[7] Salman, I. R., Rasheed, A. A., Hassan, S. A. D. H., Hussein, R. A., & Abdelzaher, M. A. (2025). Efficient Human Activity Recognition using PCA Dimensionality Reduction and GWO-Enhanced LSTM. Journal of Advanced Research in Applied Sciences and Engineering Technology, 54(2), 317-343

[8] Falih, I. Q., Alobeady, M. A., Banoon, S. R., & Saleh, M. Y. (2021). Role of Oxidized Low-density Lipoprotein in Human Diseases: A Review. Journal of Chemical Health Risks, 11.

[9] Lawi, Z. K. K., Merza, F. A., Banoon, S. R., Jabber Al-Saady, M. A. A., & Al-Abboodi, A. (2021). Mechanisms of Antioxidant Actions and their Role in many Human Diseases: A Review. Journal of Chemical Health Risks, 11.