Al-Azhar International Medical Journal

Volume 5 | Issue 8 Article 38

8-31-2024

Section: Ophthalmology

Study of Corneal Biomechanics Using Corneal Visualization by Scheimpflug Technology in Corneas with Tomographic Ectasia Susceptibility

Abdullah Elhossainy Abdelgawad
Department of Ophthalmology, Faculty of Medicine for Boys, Al-Azhar University, Cairo, Egypt

Mohamed Tarek Elnaggar
Department of Ophthalmology, Research institute of ophthalmology, Cairo, Egypt

Mohamed Eid Abdelsalam
Department of Ophthalmology, Faculty of Medicine for Boys, Al-Azhar University, Cairo, Egypt

Amro Khalil Abdullah
Department of Ophthalmology, Research institute of ophthalmology, Cairo, Egypt, abobody248@gmail.com

How to Cite This Article

Abdelgawad, Abdullah Elhossainy; Elnaggar, Mohamed Tarek; Abdelsalam, Mohamed Eid; and Abdullah, Amro Khalil (2024) "Study of Corneal Biomechanics Using Corneal Visualization by Scheimpflug Technology in Corneas with Tomographic Ectasia Susceptibility," *Al-Azhar International Medical Journal*: Vol. 5: Iss. 8, Article 38.
DOI: https://doi.org/10.58675/2682-339X.2614

ORIGINAL ARTICLE

Study of Corneal Biomechanics Using Corneal Visualization by Scheimpflug Technology in Corneas with Tomographic Ectasia Susceptibility

Abdullah E. Abdelgawad [a], Mohamed T. Elnaggar [b], Mohamed E. Abdelsalam [a], Amro A. K. Mohamed [b,*]

[a] Department of Ophthalmology, Faculty of Medicine for Boys, Al-Azhar University, Cairo, Egypt
[b] Department of Ophthalmology, Research institute of ophthalmology, Cairo, Egypt

Abstract

Background and Purpose: ***Many people seek LVC surgeries, with some complications that may develop after an intervention such as post-LASIK ectasia, studying corneal biomechanics before LVC surgeries would decrease similar complications and increase LVC surgery safety, especially in corneas with ectasia susceptibility. The goal of the study was to study corneal biomechanics using Corvis ST in corneas with tomographic ectasia susceptibility and identify the part corneal biomechanics play in ectasia identification.*** *Study* ***design: Cross-Sectional Clinical Study.*** *Setting:* ***The investigation was carried out at the Ophthalmology Department, Al-Azhar University hospitals, and the Research Institute of Ophthalmology.***

Subjects: ***The study included 33 eyes of cases of tomographic ectasia susceptibility by pentacam selected from the refractive unit from cases seeking Laser Vision Correction (LVC) surgery.***

Methods: ***All eyes were examined by Pentacam HR after a general examination was done and their D values were between 1.6 and 3 SD (Tomographic corneal ectasia susceptibility) to be involved in our study, Corneal biomechanical indices were assessed using Corvis ST.***

Results: With 100% sensitivity, 30.8 % specificity, 69% positive value for prediction, 100% negative predictive value, and an overall accuracy of 72.7% with marginal agreement between the two, abnormal TBI can predict suspicious ectasia according to CCT. According to CCT, abnormal CBI can predict suspicious ectasia with 90% sensitivity, 30.8% specificity, 66.7% overall accuracy, 66.7% positive value for prediction, and 66.7% negative predictive value, with only marginal agreement between the two.

Conclusion: ***Morphological (Pentacam) and biomechanical (Corvis ST) studies utilizing Scheimpflug camera technology are highly valuable in identifying and diagnosing corneal ectasia in the Egyptian population. These investigations can also be crucial in screening for potential corneal ectasia and could maximize (LVC) safety. But it's not a good idea to rely just on the Corvis ST biomarker because the other two technologies will provide better results. Between Corvis ST indices, the TBI and CBI were the most reliable markers for keratoconus detection. If linked to corneal topography and optical coherence tomography, it might, therefore, be regarded as a suitable enhancing biomarker for selecting candidates for refractive surgery. Additionally, corneal thickness had a significant influence on both CBI and TBI.***

Keywords: Corneal biomechanics, Corvis ST, Ectesia susceptibility

1. Introduction

Corneal ectasia is characterized by continuous attenuation, bulging, or distortion. Generally, an irrevocable situation can have an important impact on both uncorrected and corrected distant visual acuities. It can be triggered by a degenerative condition (keratoconus and pellucid marginal degeneration), an anomaly of development (keratoglobus), surgery (iatrogenic ectasia, such as post-Laser Vision Correction ectasia), or ectasia due to other causes, such as infection, which is rare .[1]

Over the last few decades, awareness of the cornea's material and structural elements has risen in clinical practice. Understanding basic biomechanical concepts has been put to use in many clinical settings, such as monitoring intraocular pressure, investigating and monitoring corneal collagen crosslinking techniques, and performing elective keratorefractive surgery.[2]

Accepted 21 August 2024.
Available online 31 August 2024

* Corresponding author at: Ophthalmology, Research institute of ophthalmology, Cairo, Egypt.
E-mail address: Abobody248@gmail.com (A. A. K. Mohamed).

https://doi.org/10.58675/2682-339X.2614

Investigating corneal biomechanics is crucial, particularly in refractive surgery, as it helps screen candidates to prevent problems and identify those who are susceptible to iatrogenic ectasia after laser vision correction (LVC) .[3]

Refractive surgery is often explored for patients of keratoconus (KC) and other ectatic conditions, especially those with subclinical complaints, due to impaired vision with spectacles and other treatments such as wearing contact lenses. Following LVC, these candidates usually have unsatisfactory to poor outcomes and have a notably higher chance of developing iatrogenic ectasia after surgery .[4]

Placido disc-based corneal topography allowed us to detect ectatic corneal diseases in earlier grades before clinical symptoms or vision impairment appeared .[5] The evaluation of the corneal surface evolved into 3D corneal tomography with the development of both front and back corneal maps and a full-thickness chart .[6] This demonstrated the tomographic approach's enhanced sensitivity for detecting subclinical (or fruste)diseases in eyes with "innocent" topographic maps.[6]

The maps can accurately indicate the presence and location of keratectasia in cases of advanced or moderate tomographic deformation. On the other hand, tomographic measurements might not be verified in mild situations .[7] In these situations, researching corneal biomechanics may help identify the issue early since it can deteriorate prior to tomographic distortion .[8] Ectatic circumstances are linked to primary biomechanical degradation, which results in secondary sequences of structural and morphological instability .[9] As a result, corneal biomechanical assessment in vivo has grown in importance for specialists and refractive surgeons .[10] Biomechanical measurement instruments have been developed as a result of this interest .[11] The Ocular Response Analyzer (ORA; Reichert Ophthalmic Instruments, NY, USA 2004) was the first device used. Next, Corvis ST was used (OCULUS, Wetzlar, Germany, 2013).

The new Corvis ST Software provides a number of indices, including the Corvis Biomechanical Index (CBI), integrated inverse radius (IIR), tomographic-biomechanical parameter (TBI), stiffness parameter at first applanation (SP-A1), biomechanical corrected IOP (bIOP), Ambrósio's Relational Thickness horizontal (ARTh), and the maximum value of deformation amplitude at the apex 2 mm from the central cornea (DA Ratio Max [2 mm]).[12]

The goal of the study was to analyze corneal biomechanics using Corvis ST in corneas with tomographic ectasia susceptibility and assess how corneal biomechanics contribute to ectasia identification.

2. Patients and methods

Patients: The research included 30 patients in total.

Study design: cross-sectional clinical study.

Setting: Ophthalmology Department, Al Azhar University Hospitals, and Research Institute of Ophthalmology.

Target population: Patients with tomographic ectasia susceptibility by pentacam selected from the refractive unit from patients seeking laser vision correction (LVC) surgery after fulfilling criteria of (LVC) surgery; the Belin Ambrosio enhanced ectasia display's D value or total deviation value, was used to calculate ectasia susceptibility. The parameter is displayed as follows: yellow (suspicious)>1.6 SD <3 SD, red (abnormal) >3 SD, or white box (normal) < 1.6 SD.

METHODS

All cases were subjected to:

A detailed medical and ophthalmic history.

An Ophthalmologic examination included refraction, visual acuity, anterior segment examination, IOP measurement, and fundus examination.

Investigations: All cases were examined by Pentacam HR, and their D value was between 1.6 and 3 SD (tomographic corneal ectasia susceptibility) to be included in our study.

Corneal biomechanical parameters were measured using a Corvis ST.

Biomechanical parameters were measured by built-in software (Version 1.4r1755).

3. Results

This study included 33 patients with ectasia susceptibility, with an age range of 19 to 39 years and a mean age of 26.7 years. Females represented 7% of them, and 57.6% of patients had righteous affection.

That K1 varied from 1 to 47.4 D, with a mean of 43.69 D. K2 ranged from 42.2 to 49.9 D, with a mean of 45.72 D. K mean ranged from 40.7 to 48 with a mean of 44.68. K max ranged from 42.9 to 52.5 D with a mean of 46.46 D. CCT ranged from 469 to 580 μm with a mean of 506.67 μm.

That SSI ranged from 0.55 to 1.18 with a mean of 0.95. SP-A1 varied from 70.9 to 135.1, with a mean of 100.02. IR ranged from 6.5 to 9.9 with a mean of 8.44, and DA Ratio varied from 3.6 to 5.5 with a mean of 4.55. CBI ranged from 0.11 to 0.94, with a mean of 0.49. Median ARTh and TBI were 440 and 0.46, respectively.

All of the DA Ratios, CBI, and TBI have a statistically significant negative connection with CCT. Additionally, CCT and SP have a positive statistically significant association.

Table 1. Relationship between the studied patients' CCT and Corvis ST parameters.

	R	P
SSI	0.223	0.213
SP-A1	0.64	<0.001**
IR	-0.542	<0.001**
DA RATIO	-0.454	0.008*
ARTH	-0.098	0.586
CBI	-0.603¥	<0.001**
TBI	-0.562¥	<0.001**

r Pearson correlation coefficient ¥ Spearman rank correlation coefficient

***p<0.05 indicates statistical significance, while p≤0.001 indicates statistically strong evidence.

That abnormal TBI can predict suspicious ectasia according to CCT with 100% sensitivity, 30.8% specificity, 69% positive value of prediction, 100% negative value of prediction, and overall accuracy of 72.7% with slight agreement between both.

That abnormal CBI can predict suspicious ectasia according to CCT with 90% sensitivity, 30.8% specificity, 66.7% positive value of prediction, 66.7% negative value of prediction, and overall accuracy of 66.7% with slight agreement between both.

That abnormal SSI can predict suspicious ectasia according to CCT with 45% sensitivity, 38.5% specificity, 52.9% positive value of prediction, 31.3% negative value of prediction, and overall accuracy of 39.3%, with no agreement between both.

That abnormal SP-A1 can predict suspicious ectasia according to CCT with 55% sensitivity, 69.2% specificity, 73.33% positive value of prediction, 50% negative value of prediction, and overall accuracy of 60.6% with slight agreement between both.

That abnormal DA Ratio predicts suspicious ectasia according to CCT with 65% sensitivity, 61.5% specificity, 72.2% positive value of prediction, 53.3% negative value of prediction, and overall accuracy of 63.6% with slight agreement between both.

That abnormal IR ratio predicts suspicious ectasia according to CCT with 55% sensitivity, 76.9% specificity, 78.6% positive value of prediction, 52.6% negative value of prediction, and an overall accuracy of 63.6%, with slight agreement between both.

With a 75% sensitivity, 38.5% specificity, 65.2% positive value of prediction, 50% negative value of prediction, and an overall accuracy of 60.6%, the aberrant ARTh ratio and CCT both predict suspicious ectasia, with no agreement between them.

Table 2. Agreement in the diagnosis of ectasia susceptibility between central corneal thickness and Corvis ST characteristics.

	SENSITIVITY	SPECIFICITY	PPV	NPV	ACCURACY	KAPPA	P
TBI	100%	30.8%	69%	100%	72.7%	0.35	0.008*
CBI	90%	30.8%	66.7%	66.7%	66.7%	0.229	0.131
SSI	45%	38.5%	52.9%	31.3%	39.3%	-0.159	0.353
SP-A1	55%	69.2%	73.3%	50%	60.6%	0.227	0.172
DA RATIO	65%	61.5%	72.2%	53.3%	63.6%	0.258	0.135
IR	55%	76.9%	78.6%	52.6%	63.6%	0.295	0.07
ARTH	75%	38.5%	65.2%	50%	60.6%	0.14	0.411

Gender and central corneal thickness show a statistically significant link (with females showing a significantly larger correlation), but the relationship between gender and D value is statistically non-significant.

Table 3. Relationship between gender and both CCT and D values.

	FEMALE	MALE	T	P
	Mean ± SD	Mean ± SD		
D VALUE	2.22 ± 0.36	2.08 ± 0.35	1.018	0.317
CCT	513.5 ± 36.25	493.0 ± 16.48	2.231	0.033*
AVERAGE	11 (50%)	9 (81.8%)	Fisher¥	0.132
ABNORMAL	11 (50%)	2 (18.2%)		

4. Discussion

The goal of this study was to figure out the significance of corneal biomechanics in ectasia identification and to assess corneal biomechanics using Corvis ST in corneas with tomographic ectasia susceptibility.

Thirty-three cases of ectasia susceptibility were involved in this study, with ages varying from 19 to 39 years old and an average age of 26.7 years. Of them, 57.6% of the patients showed signs of affection on one side, and 66.7% of the patients were female.

K1 in this study had a mean of 43.69 D and ranged from 39.1 to 47.4 D. K2 had a mean of 45.72 D and ranged from 42.2 to 49.9 D. K mean was 44.68, with a range of 40.7 to 48. K max had a mean of 46.46 D and ranged from 42.9 to 52.5 D. CCT ranged from 469 to 580 µm with a mean of 506.67 µm.

In this research, we illustrated that ISV ranged from 15 to 51, with a mean of 26.67 and 84. % had abnormal values. IVA ranged from 0.06 to 0.45 with a mean of 0.17, and 90.9% of patients had abnormal values. KI ranged from 0.99 to 1.15 with a mean of 1.03, and 90.9% had abnormal values. CKI ranged from 1 to 1.04 with a mean of 1.01, and 97% of the patients had abnormal values. Rmin ranged from 6.43 to 7.9 with a mean of 7.3, and 97% had abnormal values. The median IHA was 5.9, and 90.9% had abnormal values. The median IHD was 0.012, and 66.7% of the patients had abnormal values.

In this research, we illustrated that SSI varied from 0.55 to 1.18, with an average of 0.95. SP-A1 varied from 70.9 to 135.1, with an average of 100.02. IR ranged from 6.5 to 9.9 with a mean of 8.44; DA Ratio ranged from 3.6 to 5.5 with a mean of 4.55. CBI ranged from 0.11 to 0.94, with a mean of 0.49. The median ARTh and TBI values were 440 and 0.46, respectively.

Ambrósio illustrated that regarding corneal biomechanics, the mean values of CBI and TBI were 0.60 ± 0.2 and 0.49 ± 0.2, respectively .[13]

Augustin illustrated that the CBI mean value was 0.30 ± 0.21, with six normal values between 14 cases. The mean TBI was 0.47 ± 0.22, with two normal values in 14 cases .[14]

Peyman discovered that whereas DA Ratio, CBI, and TBI are higher in suspicious eyes, SP-A1 and ARTh values are higher in normal eyes. (Everyone $p < 0.05$).[15]

We showed a statistically significant negative association in this study between CCT and TBI, CBI, and all of the DA Ratios. Furthermore, a positive statistically significant association was seen between the levels of CCT and SP-A1. The DA Ratio and CCT had a negative correlation ($p < 0.05$), as demonstrated by Tian[16] Hon and Lam also validated the negative connection between the DA Ratio and CCT .[17]

The cross-sectional clinical investigation conducted by Kataria indicated a negative association between CCT and DA Ratio ($r = -0.554$), CBI ($r = -0.366$), and TBI ($r = -0.239$) but also demonstrated a strong positive connection with SP-A1 ($r = 0.649$, $p = 0.001$).[18]

Furthermore, between normal and subclinical keratoconic cases in the Chinese population, a recent study by Ren showed that there is a significant correlation between CCT and the following parameters (all $p < 0.001$): integrated radius ($r = -0.41$), DA Ratio ($r = -0.56$), SP-A1 ($r = 0.63$), and CBI ($r = -0.51$).[19]

Our research revealed that aberrant TBI has a 100% sensitivity, 30.8% specificity, 69% positive value of prediction, 100% negative value of prediction, and an overall accuracy of 72.7% when compared to CCT, with a modest agreement between the two.

Ambrósio demonstrated that the TBI's AUC was 0.999 for detecting clinical ectasia (KC and VAE) at a threshold of 0.5, with 98.6% specificity and 98.5% sensitivity.[13]

Baptista demonstrated that the TBI can detect manifest ectasia with 100% sensitivity and specificity with a value >0.79, and after optimization of the cutoff to 0.29, TBI can detect subclinical ectasia from eyes with normal topography in very asymmetric cases, with a higher AUROC (0.996) than CBI (0.936) or BAD-D (0.956).[20]

Wallace found that when it came to differentiating between subclinical ectasia and healthy, TBI (AUROC = 0.92, 95% CI = 0.86–0.98) performed better than BAD-D (AUROC = 0.81, P = 0.02) and CBI (AUROC = 0.78, P = 0.02). TBI demonstrated 92% accuracy, 67% specificity, and 99% sensitivity at a threshold of 0.72 for differentiating between subclinical and normal.[21]

With 90% sensitivity, 30.8% specificity, 66.7% positive value of prediction, 66.7% negative value of prediction, and an overall accuracy of 66.7% with a minor agreement between both, aberrant CBI can predict suspicious ectasia according to CCT, according to this study's findings.

Kataria demonstrated that CBI is better than SP-A1 in detecting keratoconus.[18]

Sedaghat showed that the AUC of CBI was greater than that of other biomechanical measures .[22]

According to a study by Vinciguerra, with a sensitivity and specificity of 100% and 98.4%, respectively, CBI was the most effective parameter in diagnosing keratoconus among Corvis ST parameters.[23]

4. *Conclusion*

Morphological (Pentacam) and biomechanical (Corvis ST) studies utilizing Scheimpflug camera technology are highly valuable in identifying and diagnosing corneal ectasia in the Egyptian population. These investigations can also be crucial in screening for potential corneal ectasia and could maximize (LVC) safety. But it's not a good idea to rely just on the Corvis ST biomarker because the other two technologies will provide better results. Between Corvis ST indices, the TBI and CBI were the most reliable markers for keratoconus detection. If linked to corneal topography and optical coherence tomography, it might, therefore, be regarded as a suitable enhancing biomarker for selecting candidates for refractive surgery. Additionally, corneal thickness had a significant influence on both CBI and TBI.

Disclosure

The authors have no financial interest to declare in relation to the content of this article.

Authorship

All authors have a substantial contribution to the article

Funding

No Funds : Yes

Conflicts of interest

There are no conflicts of interest.

References

1. Maharana PK, Dubey A, Jhanji V, Sharma N, Das S, Vajpayee RB, Management of advanced corneal ectasias. Br J Ophthalmol. 2016. January; 100(1):34–40.
2. Faria-Correia, F.; Luz, A.; Salomao, M.Q.; Lopes, B.T.; Ambrosio, R., Jr Corneal biomechanics: Where are we? J. Curr. Ophthalmol. 2016; 28, 97–98.
3. Ambrosio,R.,Jr.;Correia,F.F.;Lopes.; Luz, A.; Dawson, D.G.; Elsheikh, A.; Vinciguerra, R.; Vinciguerra, biomechanics in ectatic diseases: Refractive surgery implications. Open Ophthalmol. J. 2017; 11, 176–193.
4. Binder, P.S.Ectasia after laser in situ keratomileusis. J. Cataract Refract. Surg. 2003; 29, 2419.
5. Wilson, S.E: Ambrosio, R . Computerized corneal topography and its importance to wavefront technology. Cornea 2001; 20 441–454.
6. Smadja, D.; Touboul, D.; Cohen, A.; Doveh, E.; Santhiago, M.R.; Mello, G.R.; Krueger, R.R.; Colin, J.Detection of subclinical keratoconus using an automated decision tree classification. Am. J. Ophthalmol. 2013; 156, 237–246.e1.
7. Gomes, J.A.; Tan, D.; Rapuano, C.J.; Belin, M.W.; Ambrosio, R., Jr.; Guell, J.L.; Malecaze, F.; Nishida, K; Group of Panelists for the Global Delphi Panel Panel of Keratoconus and Ectatic Diseases. Global consensus on keratoconus and ectatic diseases. Cornea 2015; 34, 359–369.
8. Atalay E, Ozalp O, Yildirim N.Advances in the diagnosis and treatment of keratoconus. Ther Adv Ophthalmol. 2021; 13.
9. omes JA, Tan D, Rapuano CJ, Belin MW, Ambrosio R, Jr., Guell JL, Malecaze F, Nishida K .Global consensus on keratoconus and ectatic diseases. Cornea. 2015;34(4):359–369.
10. Bao F, Geraghty B, Wang Q, Elsheikh A. Consideration of corneal biomechanics in the diagnosis and management of keratoconus: is it important? Eye Vis. 2016; 3:18
11. Wilson A, Marshall J.A review of corneal biomechanics: mechanisms for measurement and the implications for refractive surgery. Indian J Ophthalmol. 2020;68(12):2679–2690.
12. Vinciguerra, R. et al.Detection of Keratoconus With a New Biomechanical Index J refract surg. 2016; 32, 803–810
13. Ambrósio Jr, R., Machado, A. P., Leão, E., Lyra, J. M. G., Salomão, M. Q., Esporcatte, L. G. P., & Lopes, B. T. Optimized artificial intelligence for enhanced ectasia detection using Scheimpflug-based corneal tomography and biomechanical data. Amer J Ophthalmol. 2023;251, 126-142.
14. Augustin, V. A., Son, H. S., Baur, I., Zhao, L., Auffarth, G. U., & Khoramnia, R. Detecting subclinical keratoconus by biomechanical analysis in tomographically regular keratoconus fellow eyes. Euro J Ophthalmol. 2022;32(2), 815-822.
15. Peyman, A., Sepahvand, F., Pourazizi, M., Noorshargh, P., & Forouhari, A. Corneal Biomechanics in Normal and Subclinical Keratoconus Eyes. 2023;23(1), 459
16. Tian, L., Huang, Y. F., Wang, L. Q., Bai, H., Wang, Q., Jiang, J. J., & Gao, M. Corneal biomechanical assessment using corneal visualization scheimpflug technology in keratoconic and normal eyes. J Ophthalmol, 2014; (1), 147516.
17. Hon, Y., & Lam, A. K. Corneal deformation measurement using Scheimpflug noncontact tonometry. Optometry and Vision Science. 2013;90(1), e1-e8
18. Kataria P, Padmanabhan P, Gopalakrishnan A, Padmanaban V, Mahadik S, Ambrósio R Jr (2019) Accuracy of Scheimpflug-derived corneal biomechanical and tomographic indices for detecting subclinical and mild keratectasia in a South Asian population. J Cataract Refract Surg 45:328– 336.
19. Ren S, Xu L, Fan Q, Gu Y, Yang K. Accuracy of new Corvis ST parameters for detecting subclinical and clinical keratoconus eyes in a Chinese population. Sci Rep. 2021;11(1):4962
20. Baptista, P. M., Marta, A. A., Marques, J. H., Abreu, A. C., Monteiro, S., Menéres, P., & Pinto, M. D. C. The role of corneal biomechanics in the assessment of ectasia susceptibility before laser vision correction. Clinical Ophthalmology. 2021;745-758.
21. Wallace, H. B., Vellara, H. R., Gokul, A., McGhee, C. N., & Meyer, J. J. (). Comparison of Ectasia Detection in Early Keratoconus Using Scheimpflug-Based Corneal Tomography and Biomechanical Assessments. Cornea. 2022;10-1097.
22. Sedaghat MR, Momeni-Moghaddam H, Ambrósio R Jr, Heidari HR, Maddah N, Danesh Z, Sabzi F . Diagnostic ability of corneal shape and biomechanical parameters for detecting frank keratoconus. Cornea. 2018;37:1025–1034.
23. Vinciguerra, R. et al.Detection of Keratoconus With a New Biomechanical Index J refract surg. 2016; 32, 803–810.