

***Role of Digital Ultrasound Epithelial Thickness  
Profile in Detection of Early Keratoconus***

Essay

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Ophthalmology

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# Abstract

Keratoconus [KC] is a progressive, non-inflammatory ectatic, bilateral, usually asymmetrical, disease of the cornea. It is characterized by paraxial stromal thinning that leads to conical protrusion especially at the central and inferior paracentral areas. It may presents as a subclinical form “Forme Fruste Keratoconus” [FFKC] which is a crude incomplete form of the disease that may present with non-specific symptoms such as glare and frequent change of glasses due to variable degrees of irregular myopic astigmatism.

Early detection of FFKC has become of great significance recently as it one of the most important risk factors for post LASIK ectasia. Recently, the use of a very high frequency [VHF] digital ultrasound scanning epithelial thickness profile has been introduced. This profile enables the detection of epithelial thinning over the cone of the keratoconus in a patient not showing clinical signs of ectasia and his front surface topography and anterior elevation Best Fit Sphere [BFS] show no abnormality.

The average epithelial thickness profile using Artemis VHF digital ultrasound in keratoconus revealed that the epithelium was significantly more irregular in thickness.

## **Key Words**

**Forme Fruste Keratoconus, Post-Lasik Ectasia, Artemis VHF digital ultrasound, Epithelial Thickness Profile, Keratoconus Screening.**

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

”وَقُلْ رَبِّ زِدْنِي عِلْمًا“

صدق الله العظيم

سورة " طه " الآية ١١٤

## **Dedication**

*"First and foremost, thanks are due to **ALLAH**,  
The Most beneficent, The Most Merciful"*

*My deepest gratitude to all my family especially*

***My parents,***

***My wife Dr. Sarah Hosny,***

*My father-in-law Prof. Dr. Hosny Zeid,*

*for their continuous support and prayers.*

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## List of Abbreviations

<b>ABFS</b>	Anterior elevation Best-Fit Sphere
<b>AC</b>	Anterior Chamber
<b>ACD</b>	Anterior Chamber Depth
<b>ACP</b>	Average Corneal Power
<b>ANOVA</b>	Analysis Of Variance
<b>AST</b>	Astigmatism
<b>BFS</b>	Best - Fit Sphere
<b>BSCVA</b>	Best Spectacle Corrected Visual Acuity
<b>BUT</b>	Break Up Time
<b>BZ</b>	Bowman Zone
<b>CCT</b>	Central Corneal Thickness
<b>CEI</b>	Corneal Eccentricity Index
<b>CM</b>	Confocal Microscopy
<b>CMTF</b>	Confocal Microscopy Through Focusing analysis
<b>CT</b>	Corneal Thickness
<b>CTSP</b>	Corneal Thickness Spatial Profile Graph
<b>CLEK</b>	Collaborative Longitudinal Evaluation of Keratoconus
<b>D</b>	Diopter
<b>DC</b>	Diopter Cylinder
<b>2-D</b>	Two Dimensional
<b>3-D</b>	Three Dimensional
<b>dB</b>	Decibel
<b>Diff</b>	Difference
<b>DM</b>	Descemet's Membrane
<b>EDS</b>	Ehler Danlos Syndrome
<b>En</b>	Endothelium
<b>Ep</b>	Epithelium
<b>F</b>	focal distance
<b>FDT</b>	Frequency Doubling Technology
<b>FFKC</b>	Forme Fruste Keratoconus
<b>HRS</b>	Highest Rate of Steepening
<b>I</b>	Inferior Rectus

<b>IOL</b>	Intraocular Lens
<b>IOP</b>	Intraocular Pressure
<b>I-S ratio</b>	Inferior-Superior ratio
<b>K</b>	Keratometric reading
<b>KC</b>	Keratoconus
<b>KISA%</b>	K=K-reading, I-S=Inferior-superior steepening, A=Astigmatism
<b>L</b>	Lateral Rectus
<b>LASIK</b>	laser Assisted Insitu Keratomileusis
<b>LHP</b>	Lens-Haptic Plane
<b>M</b>	Medial Rectus
<b>Max</b>	Maximum
<b>MHz</b>	Mega Hertz
<b>Min</b>	Minimum
<b>mm</b>	Millimeters
<b>m/s</b>	Meters per seconds
<b>OCT</b>	Optical Coherence Tomography
<b>OD</b>	Oculus Dexterous
<b>OLCR</b>	Optical Low Coherence Reflectometer
<b>OS</b>	Oculus Sinister
<b>PAS</b>	Periodic Acid Schiff
<b>PBFS</b>	Posterior Elevation Best - Fit Sphere
<b>PCES</b>	Pentacam Comprehensive Eye Scanner
<b>PCI</b>	Partial Coherence Interferometer
<b>PK</b>	Penetrating keratoplasty
<b>PRK</b>	Photorefractive Keratectomy
<b>QF</b>	Quality Factor
<b>R</b>	Radius of curvature
<b>SD</b>	Standard Deviation
<b>SLD</b>	Super Luminescent Diode
<b>SRI</b>	Surface Regularity Index
<b>Sim K</b>	Simulated keratometry value
<b>Sim K1</b>	Simulated K1
<b>Sim K2</b>	Simulated K2

<b>SPSS</b>	Statistical Package for the Social Science
<b>SRAX</b>	Skew of steepest Radial Axis
<b>SWAP</b>	Short-Wave Automated Preimetry
<b>TEM</b>	Transmission Electron Microscopy
<b>TGF-beta2</b>	Transforming Growth Factor-beta2
<b>TEH</b>	True Echo Harmonics
<b>THI</b>	Tissue Harmonic Imaging
<b>TIMP 1</b>	Tissue Inhibitor of Metalloproteinase1
<b>U</b>	Distance of object from the mirror
<b>UBM</b>	Ultrasound Bio-microscopy
<b>UP</b>	Ultrasound Pachymetry
<b>U/S</b>	Ultrasound
<b>V</b>	Velocity
<b>VHF</b>	Very High Frequency
<b>vs.</b>	Versus
<b>VSX1</b>	Visual System Homeobox Gene 1
<b><math>\lambda</math></b>	Lambda
<b><math>\mu\text{m}</math></b>	Micrometers

# Introduction

The most important refractive surface of the eye is the anterior surface of the cornea. The refractive power of an average anterior corneal surface of an adult is +48.8 diopters, while that of the posterior corneal surface is -5.8 diopters. Thus, for an average cornea, the total refractive power is +43.00 diopters (*Tripathi et al., 1984*).

The radius of curvature of the cornea is increased in ectatic conditions such as keratoconus, keratoglobus, and pellucid marginal degeneration, post-inflammatory and corneal ectasia (*Krachmer et al., 1984*).

Keratoconus [KC] (*Greek word: kerato—cornea , kono-cone*) is a bilateral, progressive, non-inflammatory ectatic, usually asymmetrical disease of the cornea, characterized by paraxial stromal thinning that leads to conical protrusion especially at the central and inferior para-central areas of the cornea. These results in a high degree of irregular myopic astigmatism are causing a variable amount of visual impairment (*Maguire et al., 1988*).

Commonly, KC first presents during the second decade of life. Many of the cases slowly and gradually progress in severity, but progression is highly asymmetric. In some cases, the ectasia remains stationary after its initial appearance (*Kanski et al., 2011*).

All layers of the cornea are affected in KC, as it causes thinning of the corneal stroma, rupture of the bowman's membrane and deposition of iron

in the basal epithelial cells, forming Fleisher ring. Acute hydrops may occur from breaks in the descemet's membrane (*Adel, 2012*).

In medicine, a *Forme Fruste* (French word: “crude, or unfinished, form”; *pl., Formes Frustes*) is an atypical or attenuated manifestation of a disease or syndrome, with the implication of incompleteness, partial presence or aborted state (*Belin, et al., 2006*).

The term *Forme Fruste Keratoconus* (FFKC) is used to describe a form of KC which may be suspected with the presence of non-specific symptoms such as glare and haloes together with specific criteria detected in recent diagnostic modalities.

Early detection of corneal surface abnormality has become of critical importance in patients candidate for refractive surgeries. FFKC which is a subclinical form of KC is an important risk factor for post-LASIK ectasia (*Rabinowitz, et al., 2006*).

In the early 1990s, ultrasound systems operating at 35–50 MHz became available and were used to image the anterior segment of the eye, consisting of the cornea, iris, anterior chamber, ciliary body and lens (*Pavlin et al., 1998*).

Owing to the fact that attainable axial resolution is directly related to frequency, these systems provided a four- or five-fold improvement in resolution relative to the 10 MHz scanners that were used until then (*Singh et al., 2012*). The first commercial system of this type was the Ultrasound Bio-microscopy (UBM), manufactured by Zeiss-Humphrey. This instrument was an outgrowth of the work of Pavlin and Foster and was