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

Essay

Submitted for Partial Fulfillment of Master degree of

Ophthalmology

By

Ahmed Mostafa Mosleh

M.B., B.Ch

Supervised By

Professor Dr. Hisham Fathallah Elsheikh
Professor of Ophthalmology,
Faculty of Medicine, Cairo University

Professor Dr. Ahmed Reda Awadain
Professor of Ophthalmology,
Faculty of Medicine, Cairo University

Dr. Noha Mahmoud Khalil
Lecturer of Ophthalmology,
Faculty of Medicine, Cairo University

Faculty of Medicine

Cairo University

2014

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.

بسم الله الرحمن الرحيم

” و قل رب زدني علما“

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.

Acknowledgment

I would like to express my real and deepest gratitude, respect and appreciation to ***Prof. Dr. Hisham Fathallah Elshaikh****, Professor of Ophthalmology, Cairo University, whose help, guidance, sincere concern and kindness have tremendously helped me to complete this work.*

Special thanks are due to ***Prof. Dr. Ahmed Reda Awadain****, Professor of Ophthalmology, Cairo University, for his generous effort and valuable advices throughout the work.*

My deepest gratitude to ***Dr. Noha Mahmoud Khalil****, Lecturer of Ophthalmology, Cairo University, for her honest assistance and advices that made it easier for me to complete this work.*

Last but not least, I would like to thank all my professors and colleagues in the Ophthalmology department, Cairo University whose guidance and support helped me complete my work.

INDEX

Page

List of Figures

List of Tables

List of Abbreviations

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

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

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