Axial Length and White to White Corneal Diameter in Eyes with Keratoconus

Thesis

Submitted for Partial Fulfillment of Master Degree in Ophthalmology

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Cairo-Egypt

2019

سورة البقرة الآية: ٣٢

Acknowledgment

First and foremost, I feel always indebted to **ALLAH**, *the Most Kind and Most Merciful.*

I'd like to express my respectful thanks and profound gratitude to ***Professor Dr. Dina Ezzat Mansour*** *Professor of Ophthalmology Faculty of Medicine – Ain Shams University for her keen guidance, kind supervision, valuable advice and continuous encouragement, which made possible the completion of this work.*

I am also delighted to express my deepest gratitude and thanks to ***Professor Dr. Maged Maher Salib,*** *Professor of Ophthalmology Faculty of Medicine – Ain Shams University, for his kind care, continuous supervision, valuable instructions, constant help and great assistance throughout this work.*

I am deeply thankful to ***Dr. Ahmed Taha Ismail,*** *Assistant Professor of Ophthalmolgy Faculty of Medicine – Ain Shams University, for his great help, active participation and guidance.*

Omnia Talaat Abdelwahab

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List of Abbreviations

Abb.	Full term
ACD	Anterior chamber depth
AL	Axial length
ART	Ambrósio relational thickness
AS-OCT	Anterior segment optical coherence tomography
BFS	Best-fit-sphere
BFTE	Best-fit-toric ellipsoid
CCT	Central corneal thickness
CFs	Collagen fibrils
CH	Corneal hysteresis
CT	Corneal thickness
CTSP	Corneal thickness spatial profile
CXL	Collagen crosslinking
DALK	Deep anterior lamellar keratoplasty
ECM	Extracellular matrix
ICRS	Intra-stromal corneal ring segment
IHD	Index of height decentration
IOP	Intraocular pressure
I–S	Inferior–superior
ISV	Index of Surface Variance
KC	Keratoconus
PCI	Partial coherence interferometry
PGs	Proteoglycans
PKP	Penetrating keratoplasty
PPI	Pachymetric progression index
PTI	Percentage of thickness increase
RPE	Retinal pigment epithelium
SE	Spherical equivalent
SRAX	Skewed Radial Axis
TCT	Thinnest corneal thickness
TP	Thinnest point
UBM	Ultrasound biomicroscopy
US	Ultrasonography
WTW	White to white

INTRODUCTION

Keratoconus (KC) is the most common corneal ectasia. It usually appears in the second decade of life and affects both genders and all ethnicities. The prevalence in the general population has been estimated to be approximately 54 per 100 000.[1]

Keratoconus is characterized by progressive corneal protrusion and thinning, leading to irregular astigmatism and impaired vision. The aetiology and pathogenesis of the condition are not fully understood. However, many studies discussed the early clinical detection of the disease, as well as providing optimal optical and surgical correction.[2]

Although a steep corneal curvature resulting from ectasia is the primary source of refractive error in KC patients; KC eyes are most commonly myopic, axial length (AL) is a major determinant of ocular refractive power.[3]

Horizontal or white to white (WTW) corneal diameter is one of the most important geometrical parameters of the cornea that may affect corneal biomechanics.[4]Corneal thickness (CT) and may be corneal hysteresis (CH) correlated inversely with WTW corneal diameter, on the other hand spherical equivalent(SE), AL, lens thickness, corneal radius of curvature correlated directly with WTW corneal diameter.[5]-[10]

The question is whether the myopia is a result of the ectatic and steep cornea, or an already associated elongated AL, or both?

Is KC more common in already long or short eyes? Is the ectatic corneal stretch associated with enlarged corneal diameter, axial length or posterior segment stretch?

These questions have not been well studied for KC eyes.

AIM OF THE WORK

This thesis aims at evaluating the AL and WTW corneal diameter in KC eyes and comparing them to normal (non-KC) eyes.

Chapter 1

CORNEAL ANATOMY

The transparent cornea forms the anterior portion of the outer coat of the eye and has the dual functions of protecting the inner contents of the eye as well as providing about two thirds of the eye's refractive power.[11]

Macroscopic Structure:

Macroscopically the cornea is aspheric in shape with wide variety of ocular dimensions exist in the normal population. The radius of curvature of its central anterior surface is about 7.8 mm in. The central corneal thickness (CCT) is approximately 520 µm and increases towards the periphery where it can reach 650 µm.[12]

Microscopic Structure and Composition:

From front to back the cornea consists of five layers, the corneal epithelium, Bowman's layer, the corneal stroma, Descemet's membrane and the corneal endothelium.[12](Figure1) [13]

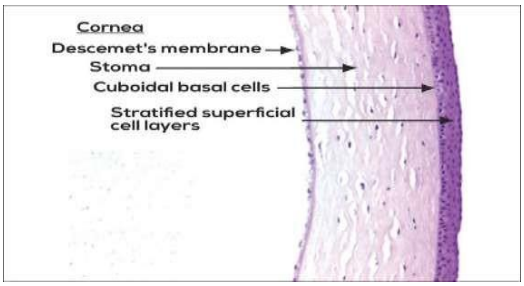

Figure (1): Corneal microscopic picture.[13].

With the experience of corneal transplants, Dua described a layer that exists between the corneal stroma and Descemet's membrane.[14]

Epithelium:

The corneal epithelium is a tight, protective, stratified squamous epithelium which typically comprises 5-7 layers of cells that continually sheds cells to the environment and is firmly attached to the underlying stroma.[15](Figure2)

Bowman's layer:

Bowman's layer is composed of collagen fibrils (CFs). These fibrils are not ordered in bundles; individual fibrils run in various directions to form a sheet about 8-12 μm thick as a whole. Bowman's layer contained no cellular components except occasional unmyelinated nerve fibers penetrating the layer to the corneal epithelium.[16] (Figure 2)

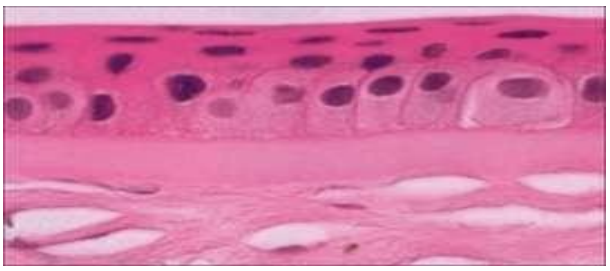

Figure (2): Epithelium and Bowman's layer.[13]

Stroma:

Corneal stroma is a collagen-rich central layer that comprises nearly 90% of the corneal thickness.[11]

The corneal stroma has three primary non-aqueous constituents: collagens, proteoglycans (PGs) and cells (keratocytes). It also contains specialized glycoproteins[17] and, of course, ions that play an important role in organizing the collagen fibers (CFs) in order to maintain transparency.[18]

The collagen in the stroma is laid down within lamellae. Each lamella contains a highly oriented array of CFs with their attendant PGs. Lamellar size varies considerably as the anterior lamellae are 0.5-30 μm wide and 0.2-1.2 μm thick while those in the posterior stroma are 100-200 μm wide and 1.0-2.5 μm thick.[16]

The anterior stroma exhibits substantial weaving of continuous lamellae in the antero-posterior direction while in the posterior stroma, the lamellae run nearly exclusively in the plane of the cornea.[19]

In addition to structural differences in the lamellar organization, there are some compositional gradients of interest. In general, the posterior stromal tissue is wetter than the anterior stromal tissue.[20]

Descemet's membrane:

The endothelium has a thick basement membrane (referred to as Descemet's membrane) which is thought to be a secretory product the endothelium itself.[21]

Endothelium:

The corneal endothelium is a 4-6 µm thick transporting monolayer of approximately 400,000 cells arranged in a hexagonal mosaic. The cells of the endothelium are conjoined at their borders with incomplete tight junctional complexes.[21]

Corneal endothelial cells control corneal hydration and they do not readily regenerate and normal age-related loss or damage to the layer is compensated for polymegathism and pleomorphism of the surrounding cells.[22](Figure3)

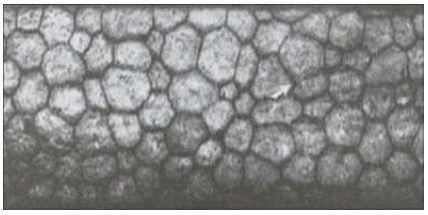

Figure (3): Corneal endothelium by specular microscope(SM).[13]