ASSESSMENT OF CORNEAL THICKNESS IN HEALTHY AND DISEASED CORNEAS BY DIFFERENT IMAGING TECHNIQUES

Thesis

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ACA: anterior chamber angle

AS: anterior segment

AS OCT: anterior segment OCT

BFS: best fit sphere

CCD: charge coupled device

CCT: central corneal thickness

CT: corneal thickness

CXL: collagen cross linking

ECM: extra cellular matrix

Intacs: intracorneal ring segments

KC: keratoconus

LASIK: laser assisted in situ keratomileusis

LED: light emitted diode

LOX: lysyloxidase

MD: mean difference

MMP: matrix metalloproteinases

OCT: optical coherence tomography

PPI: pachymetric progression index

PRK: photorefractive keratectomy

SD: stander deviation

SD OCT: spectral domain OCT

SNR: signal to noise ratio

SOD: superoxidedismutase

SS OCT: swept source OCT

TCT: thinnest corneal thickness

TD OCT: time domain OCT

TL: thinnest location

TMS: topographic modeling system

UBM: ultrasound biomicroscopy

UHR OCT: ultra-high resolution OCT

US: ultrasound

USP: ultrasound pachymetry

UV: ultraviolet

ABSTRACT

Background: Accurate measurement of corneal thickness (CT) is highly important in decision making and planning for refractive surgery. It is also important in diagnosis of keratoconus, measuring intraocular pressure and monitoring corneal edema. Different methods are available for CT measurement including optical and ultrasound based techniques.
Aim of the Study: was to assess the diagnostic accuracy of optical (AS OCT and Pentacam) and ultrasound imaging systems (ultrasound pachymetry) in measuring corneal thickness in healthy and diseased corneas.
Materials and Methodology: Three groups were included: 20 healthy corneas, 20 eyes with keratoconus (KC) and 20 eyes with corneal scars. In all cases central corneal thickness (CCT) was measured using ultrasound pachymetry (USP), Pentacam and anterior segment optical coherence tomography (AS OCT).
Results: In normal corneas the mean difference (MD) between USP and Pentacam, USP and OCT & Pentacam and OCT was (-1.3±9.4, 0.4±10.4 &1.7±10.7µm) which is statistically insignificant between the 3 pairs with coefficient of determination 1 between the 3 pairs. In KC group the mean difference (MD) between USP and Pentacam (-7.7±15.1 µm) was statistically significant while the MD between USP and OCT & Pentacam and OCT (4.7±15.7 and 12.3±14.1 µm) was not statistically significant. In scar group the MD between the 3 pairs (-1.1±79.1, -13.6±20.8 &-12.5±73.0) with statistically significant difference between USP and OCT. Coefficient of determination was found 0.9.
Conclusion: USP, AS OCT and Pentacam have high agreement regarding CCT measurement in normal corneas. However, when we studied KC and scarred corneas we found that OCT measurements are higher than those of Pentacam in most of the cases regarding CCT.

Keywords: CCT, Pentacam, AS OCT.

Introduction

The measurement of corneal thickness (CT) is highly important in decision making and planning for refractive surgery, in diagnosis of keratoconus (KC), measuring intraocular pressure (IOP), and monitoring corneal edema. [1]

For these reasons, anterior segment (AS) imaging became a rapidly advancing field. New modalities such as rotating Scheimpflug imaging, based on the principle introduced by Theodor Scheimpflug, and anterior segment optical coherence tomography (AS OCT) are now used to replace or supplement the previously established methods such as Orbscan scanning slit tomography (Bausch & Lomb, Inc., Rochester, NY) and ultrasound biomicroscopy (UBM). [2, 3]

The traditional method, ultrasound pachymetry (USP), was considered as the standard method due to its reliability, ease of use and low cost in comparison to recent modalities. However, recent modalities offer pachymetric mapping which was not available with USP and is of a great importance in refractive surgery and corneal ectasia. [1]

Anatomy of the cornea

Cornea is the primary structural barrier of the eye. It acts as the anterior refractive surface through being transparent avascular connective tissue. Its clarity is maintained through many structural and physiological factors. [4]

In adults the average horizontal corneal diameter is 11.5 to 12 mm which is about 1 mm larger than the vertical diameter. Regarding the thickness, it is about 0.5 mm at the center which increase gradually toward the periphery. [5]

Microscopically the cornea consists of five layers (figure 1) which are epithelium, Bowman's layer, stroma, Descemet membrane, and endothelium. [4] In 2013, a sixth layer, Dua's layer, was described in between the stroma and Descemet membrane. [6]

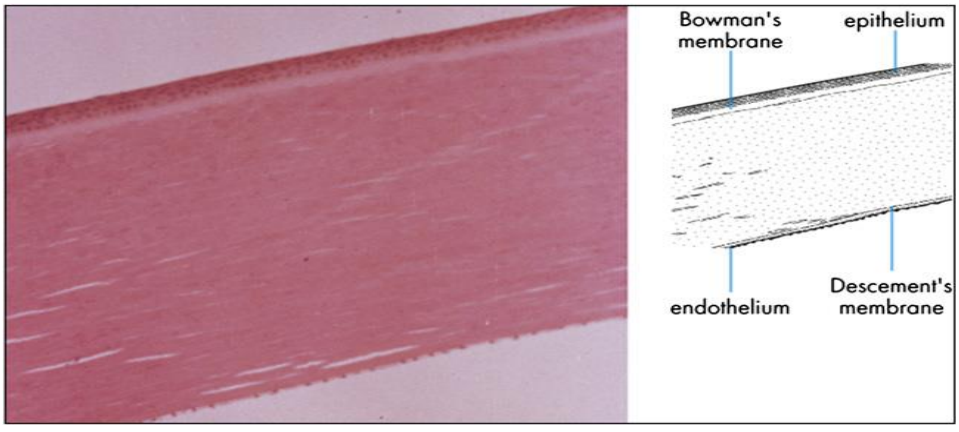

Figure 1 Light microscopic picture of normal cornea [7]

Epithelium

Corneal epithelium is a uniform stratified non-keratinized squamous epithelium acting as the first barrier against the external environment and as an integral part of tear film-cornea interface that is critical to the refractive power of the eye. Epithelium is composed of five to six layers resting on epithelial basement membrane of 0.5 µm thickness. Corneal epithelial thickness is not homogeneous and tends to alter to compensate for irregular corneal stromal surface. The mean epithelial thickness at the corneal vertex is 53.4±4.6 µm. [8, 4, 9]

The most superficial cells are two to three layers of flat polygonal cells with extensive apical microvilli covered by a glycocalyceal layer. The superficial cells are connected by tight junctional complexes which prevent tear film from entering intercellular spaces and prevent toxins and microorganisms from penetrating deep layers. Deep to the superficial cells are two to three layers of wing cells which are less flat than the superficial cells but with similar tight lateral junctions. Deeply there is a single layer of columnar epithelium about 20 µm long which is called the basal layer attached to the underlying basement membrane by hemi-desmosomes. [4,7]