Comparative Study of Endothelial Cell Loss Using Infiniti versus Signature Machines in Phacoemulsification in Senile Cataract

Thesis Submitted for Fulfillment of Master Degree

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LIST OF ABBREVIATIONS

ACD: Anterior chamber depth

APT: Absolute phaco time

aPACG: Acute primary angle closure glaucoma

BSS: Balanced salt solution

CCC: Continuous curvilinear capsulorrhexis

CES: Corneal Exhaustion Syndrome

CV: Coefficient of Variation

ECC: Endothelial cell count

ECD: Endothelial cell density

ECL: Endothelial cell loss

FS: Fluorescin Sodium

GV: Gentian Violet

ICG: Indocyanine green

IOL: Intraocular lens

IOP: Intraocular pressure

IP: Imbibition Pressure

LASIK: Laser in situ keratomileusis

LOCS III: Lens Opacity Classification System III

MB: Methylene Blue

OVDs: Ophthalmic viscosurgical devices

PMMA: Polymethylmethacrylate

PXE: Pseudo exfoliation syndrome

RGP: Rigid gas-permeable

SP: Swelling pressure

SD: Standard Deviation

SST: Soft-shell technique

TB: Tryptan Blue

TEM: Transmission Electron Microscopy

USST: Ultimate soft-shell technique

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INTRODUCTION

The human corneal endothelium is physiologically the most important monolayer of the cornea. These unique hexagonal cells act as a barrier for fluid moving into the stroma, which because of the glycosaminoglycan composition can adsorb large amounts of fluid creating an edematous cornea that can lead to the loss of vision. As the most metabolically active cells in the cornea, fluid pumps operate continuously to actively move fluid from the stroma back into the anterior chamber of the eye. The dynamic balance between the "leaky" barrier and active pump regulates corneal hydration, keeping the cornea transparent. Corneal blindness, the situation where the retina is normal but the cornea becomes edematous, is often caused by endothelial dysfunction and is the second leading cause of visual blindness **(BeuermanR et al, 2011).**

The corneal endothelium consists of a monolayer of polygonal cells, the numerical density of which is highest at birth and declines slowly but steadily thereafter. A minimal numerical density of 400–500 cells/mm^2 is required to sustain the pumping activity of the endothelium. Dysfunction results in corneal decompensation and loss of vision. The fact that the endothelium becomes gradually depleted of cells rather than compensating for its losses reflects the limited capacity of these cells to regenerate. This situation may become exacerbated by losses incurred during the course of certain diseases or after intraocular surgery **(Ventura A, 2001).**

Factors which contribute to a decrease in endothelial cells density include age, trauma, intraocular surgery and certain corneal diseases **(Wilczynski M et al, 2006).**

Cataract is one of the leading causes of preventable and curable blindness worldwide. Recently, especially with the advancement of technology, there has been a trend towards making cataract surgery not simply a procedure to remove the opaque lens, but additionally to aim at achieving the best possible visual outcome with optimal safety and minimum invasiveness.

These goals have created a trend toward using a smaller wound during phacoemulsification that is associated with less surgically induced astigmatism, better fluidics, and phaco power modulation to allow for faster recovery with less tissue damage and inflammation. The problem facing ophthalmic surgeons after performing cataract surgery with intraocular lens implantation may be corneal decompensation due to endothelial cell loss **(Kohnen T, 2011).**

At every stage of a cataract procedure the surgeon has options that can optimize corneal endothelial safety. The relevant parameters include the machines, materials, and techniques used, and patient characteristics such as stage of the cataract, age of the patient, and the presence of corneal diseases **(Nuijts R, 2008).**

Prior to 1970s, the study of corneal endothelium was limited to biomicroscopic evaluation for guttata, fold and keratic precipitates. Thereafter specular microscope has made the evaluation of endothelium possible. The instrument projects light onto the cornea and captures the image that is reflected from the optical interface between the corneal endothelium and the aqueous humor. The reflected image is analyzed by the instrument and displayed as a specular photomicrograph. In clinical practice, specular microscopy is the most accurate way to examine the corneal endothelium **(Thomas C, 2009).**

The aim of quantitative specular microscopic analysis is to assign values to endothelial cells that can provide a measure of their functional states. It makes the measurement of mean cell density (MCD), mean cell area (MCA) possible as well as measurement of variations in cell size (polymegathism) and cell shape (polymorphism). The specular microscope has been used to establish and compare normative data for endothelium parameters among ethnic groups as well as sexes. These parameters provide an index of the functional capacity of the endothelium**.** Endothelial cell analysis provides important clinical information on corneal function and viability. The determination of the endothelial cell density (ECD) has become an accepted practice both clinically and in research to provide information on the cell layer needed to maintain corneal transparency. The potential clinical uses include the assessment of the endothelium in donor corneas, the monitoring of different anterior segment surgery techniques,

and the effects of intraocular surgery, such as cataract surgery or implantation of phakic intraocular lenses. When performing intraocular procedures, endothelial trauma should be minimized, and specular endothelial microscopy is recognized as being essential in evaluating the safety of new intraocular or corneal surgical procedures and intraocular lenses**(MoghimiS et al, 2006).**

AIM OF WORK

The aim of this work is to compare the endothelial cell loss after phacoemulsification using the Infiniti and the Signature machines.

Primary outcome:

Endothelial cell loss

Secondary outcome parameters:

1-Intraoperative complications

2-Postoperative complications

3-Phacotime, U/S power used, vacuum and flow rates during surgery

4-Amount of fluid entering the eye

REVIEW OF LITERATURE

Anatomy of the Cornea

The cornea is the transparent front part of the eye that covers the iris, pupil, and anterior chamber. The cornea, with the anterior chamber and lens, refracts light, with the cornea accounting for approximately two-thirds of the eye's total optical power. In humans, the refractive power of the cornea is approximately 43 diopters. While the cornea contributes most of the eye's focusing power, its focus is fixed. The curvature of the lens, on the other hand, can be adjusted to "tune" the focus depending upon the object's distance **(Cassin B et al, 2007**).

The cornea has unmyelinatednerve endings sensitive to touch, temperature and chemicals; a touch of the cornea causes an involuntary reflex to close the eyelid. Because transparency is of prime importance the cornea does not have blood vessels; it receives nutrients via diffusion from the tear fluid through the outside surface and the aqueous humour through the inside surface, and also from neurotrophins supplied by nerve fibers that innervate it. In humans, the elliptical anterior surface of the cornea has a diameter of about 11.5 mm horizontally and 10.5mm vertically, while the posterior surface is circular with a diameter of 11.5mm. Corneal thickness is 0.5–0.6 mm in the center and 0.6–0.8 mm at the periphery. Transparency, avascularity, the presence of immature resident immune cells, and immunologic privilege makes the cornea a very special tissue. The cornea has no blood supply; it gets oxygen directly through the air. Oxygen first dissolves in the tears and then diffuses throughout the cornea.

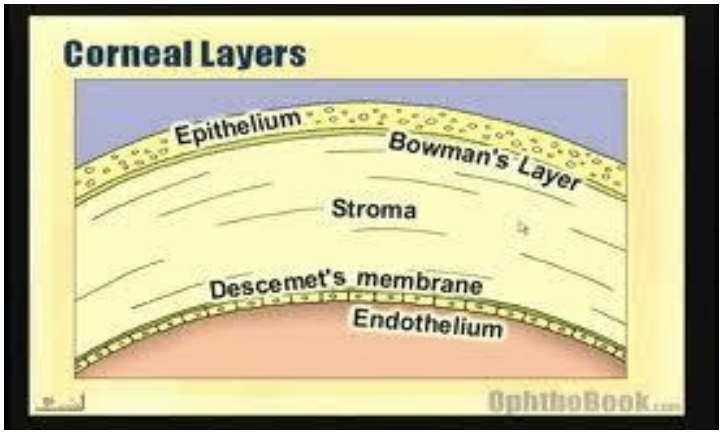

Figure 1: Corneal layers (ophthobooks.com)

Layers of the cornea:

Scientists previously believed the cornea to be composed of five layers, but a new layer has been recently discovered (Dua's layer). From front to back the layers of the cornea are:

1.Corneal epithelium: an exceedingly thin multicellular epithelial tissue layer (non-keratinized stratified squamous epithelium) of fast-growing and easily regenerated cells, kept moist with tears. Irregularity or edema of the corneal epithelium disrupts the smoothness of the air/tear-film interface, the most significant component of the total refractive power of the eye, thereby reducing visual acuity

2.Bowman's layer (also known as the *anterior limiting membrane*, when in fact it is not a membrane but a condensed layer of collagen): a tough layer that protects the corneal stroma, consisting of a similar irregularly arranged collagen fibers, mainly type I collagen fibrils, essentially a type of stroma. These fibrils interact with and attach on to each other **(Dolores M, 2002).**

3. Corneal stroma (also substantia propria): a thick, transparent middle layer, consisting of regularly arranged collagen fibers along with sparsely distributed interconnected keratocytes,

which are the cells for general repair and maintenance. They are parallel and are superimposed like book pages. The corneal stroma consists of approximately 200 layers of mainly type I collagen fibrils. Up to 90% of the corneal thickness is composed of stroma.

There are 2 theories of how transparency in the cornea comes about:

- The lattice arrangements of the collagen fibrils in the stroma. The light scatter by individual fibrils is cancelled by destructive interference from the scattered light from other individual fibrils.
- The spacing of the neighboring collagen fibrils in the stroma must be < 200 nm for there to be transparency **(Daxer A et al, 1998).**

4. Dua's layer: This new layer has been dubbed the Dua's Layer after the academic Professor HarminderDua who discovered it. Having identified this new and distinct layer deep in the tissue of the cornea, we can now exploit its presence to make operations much safer and simpler for patients.

From a clinical perspective, there are many diseases that affect the back of the cornea which clinicians across the world are already beginning to relate to the presence, absence or tear in this layer.Scientists have discovered that Dua's layer is located towards the back of cornea, between the corneal stroma and the Descemet's membrane. Although it is just 15 microns thick – the entire cornea is around 550 microns thick or 0.5mm – it is incredibly tough and is strong enough to be able to withstand one and a half to two bars of pressure **(Dua H et al, 2013).**

Scientists proved the existence of the layer by simulating human corneal transplants and grafts on eyes donated for research purposes to eye banks located in Bristol and Manchester. During this surgery, tiny bubbles of air were injected into the cornea to gently separate the different layers. The scientists then subjected the separated layers to electron microscopy, allowing them to study them at many thousand times their actual size.Understanding the properties and location of the new Dua's layer could help surgeons to better identify where in the cornea these bubbles