In Vitro and In Vivo Analysis of New Wound Configurations with the Femtec 80kHz Femtosecond Laser

Thesis submitted for the partial fulfillment of the MD degree in ophthalmology

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LIST OF ABBREVIATIONS

αSMA Alpha Smooth Muscle Actin
AC Anterior Chamber
ALK Anterior Lamellar Keratoplasty
ANOVA Analysis of Variance
AS-OCT Anterior Segment Optical Coherence Tomography
bFGF basic Fibroblast Growth Factor
BSCVA Best Spectacle Corrected Visual Acuity
BSS Balanced Salt Solution
CCT Central Corneal Thickness
CO_2 Carbon Dioxide
D Diopter
DALK Deep Anterior Lamellar Keratoplasty
DLEK Deep Lamellar Endothelial Keratoplasty
DM Descemet's Membrane
DMAEK Descemet Membrane Automated Endothelial Keratoplasty
DMEK Descemet Membrane Endothelial Keratoplasty
DSAEK Descemet Stripping Automated Endothelial Keratoplasty
DSEK Descemet Stripping Endothelial Keratoplasty
EC Endothelial Cell
ECM Extracellular Matrix
EDM Endothelium- Descemet Membrane
EK Endothelial Keratoplasty
FS Femtosecond
FLEK Femtosecond Laser Enabled Keratoplasty
FLAK Femtosecond Laser-Assisted Anterior Lamellar Keratoplasty
g gram
H&L heavy and light chains
HRP Horseradish peroxidase
H_2O water
IOL Intra-Ocular Lens
J Joule
kHz Kilohertz
KP Keratoplasty
LASIK Laser Assisted in Situ Keratomileusis
LK Lamellar Keratoplasty
Log MAR logarithm of Minimal Angle of Resolution
mth month

MMP(s) Matrix Metalloprotinase(s)
µJ microjoule
µm micrometer
mg milligram
mJmillijoule
ml milliliter
mm millimeter
mmHgmillimeter of mercury
MEM minimum essential medium
nmnanometer
Nd:YAG Neodymium-doped Yttrium Aluminum Garnet
Nd:YLF Neodymium-doped Yttrium Lithium Fluoride

OBL Opaque Bubble Layer

OCT Optical Coherence Tomography
P Probability
PBS Phosphate Buffered Saline
PFAParaformaldhyde
PKP Penetrating Keratoplasty
PLK Posterior Lamellar Keratoplasty
PO Postoperative
PRK Photorefractive Keratectomy
r range
RK Radial Keratotomy
SALK Superficial Anterior Lamellar Keratoplasty
SD Standard Deviation
UCVA Uncorrected Visual Acuity///////Acuity
wkweek

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AIM OF THE WORK

Our project aimed at two main objectives:

1. To analyze and compare cut quality of new 80 kHz Femtec Laser to 40 kHz.

2. To analyze wound healing response after femtosecond laser treatment for presbyopia (INTRACOR) and lamellar keratoplasty.

INTRODUCTION

Lasers with ultrafast pulses have been developed to decrease the energy necessary to incise tissues and to decrease damage to surrounding tissues. [1]

Femtosecond solid-state lasers are gaining more popularity in many fields of medicine. They are already used in neurosurgery and dentistry. Now, femtosecond lasers also offer advantages for ophthalmologists, due to their precise performance and the fact that the cornea is transparent for the laser beam (in contrast to excimer laser beams).[2]

Currently, five US Food and Drug Administration- approved laser systems are available on the market: IntraLase FS laser, Femtec, Femto LDV, VisuMax and WaveLight® FS200. All of these systems are based on the same working principle. [3]

Now, surgeons can use the Femtec femtosecond laser to perform many different procedures and make more precise cuts than ever before from penetrating keratoplasty (PKP) to astigmatic keratotomy (AK). While the Femtec laser is similar to the IntraLase, it does have some special characteristics including a patented patient interface, which mimics corneal curvature. As a result, the natural shape of the cornea can be maintained and less suction is needed when attaching the device to the eye than with the IntraLase. Because there is less suction on the eye, there is also less pressure inside the eye during the procedure. As a result, patients no longer experience vision blackouts during a procedure. However, the capability that most distinguishes it from other existing platforms is its potential to be used to perform intrastromal refractive surgery with no flap. [4, 5]

Automated microkeratome lamellar keratoplasty remains the most popular technique for lamellar corneal surgery but the precision of the corneal cut at any corneal depth with the femtosecond laser is an important improvement in this technique. Donor lenticulae and corneal cuttings performed with the Femtec femtosecond laser can be used in the successful management of eyes requiring anterior lamellar keratoplasty. [6]

One treatment for presbyopia that has garnered much attention is INTRACOR, or intrastromal correction of presbyopia. Until recently, laser procedures for presbyopia correction required the creation of an opening into the cornea and removal of the epithelium to apply treatment to the deeper stroma. However, the INTRACOR presbyopia treatment with the Femtec femtosecond laser changes that. It allows focusing the treatment directly into the stroma, without cutting the cornea or creating an intrastromal pocket. Additionally, this intrastromal correction does not require removal of the epithelium. Therefore, the structural integrity of the cornea is maintained. INTRACOR has a minimal rate of infection and promotes wound healing with a quick procedure time. [7]

CORNEAL ANATOMY

To help understand the wound healing response after keratorefractive procedures, it is first important to review the structure of the cornea. Understanding the structure also can help explain some of the complications that can arise as a result of refractive surgery.[8]

The cornea is an avascular and transparent structure situated in front of the eye. Thestructural and physiological properties of the cornea determine its optical performance torefract light. The cornea is the most powerful refractive lens of the eye comprising onaverage 45 diopters (D) of the approximately 60-70 D total refractive power of the eye. The centralthickness of the cornea is between 500 to 550 micrometers (μm) and 600 to 700 μm at the cornealperiphery.[9] Thisdifference in thickness between the periphery and the center generates a disparity incurvature creating an aspheric optical system. The cornea has an elliptical shape when viewed frontally; this configuration arises from an extension of opaque scleral tissue thatcovers the cornea superiorly and inferiorly. In the adult cornea, the horizontal and verticalaverage diameters are 12 millimeters (mm) (range 11 to 12.5 mm) and 11 mm (range, 10 to 11.5 mm),respectively. [10]

Tear film

The pre-corneal tear film supports and maintains the ocular surface. It lubricates theepithelium, protects the cornea from external agents, modulates wound healing through itscomponents and, secondary to the air-tear interface, creates the first refractive surface.