WAVEFRONT VERSUS TOPOGRAPHY GUIDED CUSTOMIZED ABLATION IN CORRECTION OF REFRACTIVE ERRORS

Essay

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SUMMARY

For more than a century there has been awareness of the fact that the eye is not a perfect optical system and that it suffers optical aberrations other than defocus and astigmatism.

The naturally occurring higher order aberrations, combined with large increases in the eye's higher order aberrations induced by refractive surgery can decrease visual performance despite the elimination of spherocylindrical errors.

Wavefront aberration is defined as the deviation between the reference wavefront that comes from an ideal optic system and the wavefront that originates from a measured optical system.

In the wavefront guided ablation, by using a wavefront sensor, the wavefront of the eye is measured and approximated in Zernike polynomials. The treatment goals are to correct the refractive error, minimize induction of HOAs, and reduce preexisting aberrations.

Corneal-topography-guided ablation has been attempted on patients with regular and irregular astigmatism, decentered ablations, and central islands. Once the topography is taken, data are copied and the ablation profile is calculated on site using a special software called TopoLink ,The results have been encouraging with central islands, regular astigmatism, and decentered ablations, but the system requires refinement with irregular astigmatism.

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Last but not least, to the soul of my father who had always dreamt of this day, Hopping that I made your dream comes true …

CONTENTS

LIST OF ABBREVIATIONS

µm : Micrometer

ALK : Automated Lamellar Keratoplasty

ArF : Argon Flouride

BCVA : Best Corrected Visual Acuity

CAP : Custom Ablation Pattern

C-CAP : Custom Contoured Ablation Pattern

CCD : Charge couple device.

CIPTA : Corneal Interactive Programmed Topographic Ablation

D : Diopter

FDA : Food & Drug Administration

HOAs : Higher Order Aberrations

IOLs : Intraocular Lens

IOP : Intraocular Pressure

LASIK : Laser Assisted Stromal In situ Keratomileusis

LOAs : Lower Order Aberrations

OPD : Optical Path Difference

PRK : Photorefractive Keratectomy

RMS : Root Mean Square.

SRR : Spatial Resolved Refractometer

TOSCA : Topographic Simulated Customized Ablation

UCVA : Uncorrected Visual Acuity

WASCA : Wavefront Aberration Supported Corneal Ablation

WFG LASIK : Wavefront Guided Lasik

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

The concept of using the measurements that reflects eye's visual function seems logical in refractive surgical ablation planning, since the goal of refractive surgery is improvement of the existing visual function ***(stoganovi and Suput, 2005)***.

Wavefront guided customization is one of the most successful methods of corneal ablation. This essential consists of the wavefront analysis, the coupling of the wavefront map to excimer laser machine and consequently the excimer laser delivery in accordance with the wavefront profile. The first wavefront guided LASIK was performed by Dr Theo Seiler in 1999 ***(Sullivan and Sharma, 2005)***.

The potential benefits of wavefront Guided Custom LASIK (Laser in situ karatomileusis) are greater chances of achieving a visual acuity better than 20/20, better contrast sensitivity, night vision with less chances of night vision disturbances and glare. It may be useful in treating patients for primary refractive error and also in patients who are having problems after previous refractive surgery such as photorefractive keratectomy (PRK) and LASIK. This may apply for cases that have higher order aberrations, decentered ablation or night vision problems ***(Sullivan and Sharma, 2005)***.

A variety of software is available which link the topography system to excimer laser delivery systems in order to achieve the topography assisted customized ablation ***(Pangtey et al., 2005)***.

The Concept of topography assisted customized ablation was first suggested by **Seitz et al** in 1998 in experimental studies. This was made possible due to various topography based software and the technology of the flying spot excimer lasers ***(Pangtey et al., 2005)***.

The indication of topography assisted customized ablation vary from the corrections of primary errors to the correction of aberrations due to iatrogenic causes, following corneal trauma and keratitis. The results have been encouraging in regular astigmatism and decentered ablation but require refinement with irregular astigmatism ***(Pangtey et al., 2005)***.

AIM OF THE WORK

To Highlight the role of the wavefront versus topography, customized ablation in correction of the refractive errors.

EXCIMER LASERS

Physical principle:

The term excimer is derived from "excited dimmer" which consists of an inert gases (xenon, krypton, and argon) and a halide gases (fluoride and chloride), specifically argon and fluoride gaseous elements which are excited to a higher energy state by thousands of volts of electricity. The argon and fluoride (ArF) elements are in very small concentrations in a helium mixture known as premix. The elements combine to form an unstable compound, which rapidly dissociates, releasing ultraviolet light energy ***(Machat, 1996).***

The advantage of ArF excimer laser represented in its capability of excising corneal tissue with submicron precision as well as submicron collateral damage. The excimer laser removes 0.25-micron per pulse and damage an additional 0.25-micron of adjacent corneal tissue. The excimer laser is therefore 50 to 1000 times more precise than any other ophthalmic laser in this regard ***(Mrochen and Seiler, 2001).***

Excimer lasers can produce ultraviolet energy at various wavelengths depending upon the gas element utilized. Ultraviolet light energy of wavelength 193nm was associated with smoother ablation effects at lower energy densities and did not exhibit mutagenic or cataractogenic behavior ***(Green et al, 1987).***

Basic Concepts of excimer Laser:

The excimer laser consists of three vital components: the lasing medium, the lasing cavity, and the optical delivery system. The computer controls the magnitude and pattern of the distribution of laser energy delivered to the cornea and the diameter of the laser aperture **figure (1)** ***(Flowers et al .2001).***

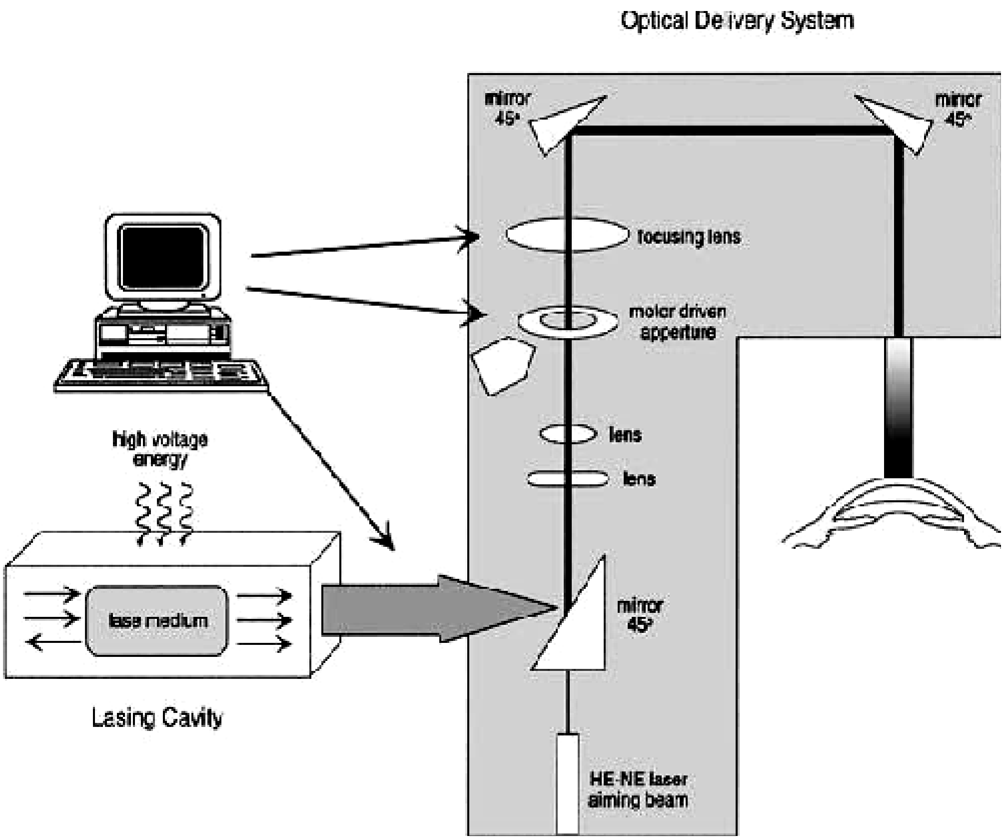

Fig. (1): Excimer laser system ***(Flowers et al. 2001)***

EXCIMER LASER DELIVERY SYSTEMS

There are three basic laser delivery systems: broad beam, scanning slit beam and flying spot ***(Sharma et al., 2005)***.

Broad beam system

This was the first generation with wide-field ablation. It uses stationary, broad and circular beam (6.0 - 8.0 mm) of the excimer laser. It has shorter operative time, lower repetition rate and the need for eye tracking system is not required. However, it requires high energy output, more frequent maintenance of optical components, an increased possibility of central islands, and increase in the overall running cost ***(Fiore et al., 2001).***

Scanning slit laser system

It uses a rectangular slit shaped beam of light that scans across an aperture within the path of the beam and uniformly removes the corneal tissue with several successive pulses of laser. The small area of ablation which characterizes slit-scanning lasers produces smoother ablative surface and also reduces the complications of central islands ***(Sharma et al., 2005)***.

Fig. (2): Slit Scanning Laser ***(Sharma et al., 2005).***